Economic Commission for Africa

UNITED NATIONS REGIONAL CARTOGRAPHIC CONFERENCE FOR AFRICA

1-12 July 1963, Nairobi, Kenya

Vol. 2 - Proceedings of the Conference and Technical Papers

UNITED NATIONS
New York, 1966

The official records of the proceedings of the United Nations Regional Cartographic Conference for Africa are being issued in two volumes: volume 1, *Report of the Conference* (E/CONF.43/105), and the present publication, volume 2, *Proceedings of the Conference and Technical Papers* which contains the summary records of the plenary meetings and the technical and background papers presented to the Conference by the participants.

NOTE

Symbols of United Nations documents are composed of capital letters combined with figures. Mention of such a symbol indicates a reference to a United Nations document.

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FOREWORD

In accordance with the practice followed for the United Nations regional cartographic conferences, the official records of the first United Nations Regional Cartographic Conference for Africa, held in Nairobi from 1 to 12 July 1963, are issued in two volumes: volume 1, *Report of the Conference*[1] and the present publication, volume 2, *Proceedings of the Conference and Technical Papers.*

The present volume contains three parts and an annex: part I, the summary records of the ten plenary meetings; part II, the reports by Governments and international organizations on their cartographic activities for the African continent. These reports are reproduced in the alphabetical order of participating countries and in the case of several reports by one country, they are grouped by technical subjects and follow the order of technical items of the agenda of the Conference; and part III, the studies, reports and communications submitted for consideration by or information of the Conference by participating Governments and organizations, as well as by the Secretariat of the United Nations. The annex reproduces the rules of procedures adopted by the Conference.

All the reports and papers have been edited and consolidated as necessary in accordance with United Nations practice and requirements. For instance, a paper or parts of papers which have already been published elsewhere are not reproduced in this volume, but full information on the publication in which they appear is given in a reference.

The Standing Committee on Industry, Natural Resources and Transport of the Economic Commission for Africa considered the report of the Conference at its second session and endorsed all the resolutions of the Conference,[2] and the Commission itself, at its sixth session, included in the programme of work for 1965-1966, a project for convening a second United Nations regional cartographic conference for Africa in 1966.[3]

The designations employed and the presentation of the material in this publication do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations concerning the legal status of any country or territory or of its authorities, or concerning the delimitation of its frontiers.

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[1] *United Nations Regional Cartographic Conference for Africa*, volume 1, *Report of the Conference*, E/CONF.43/105 (Sales No.: 64.I.2).

[2] E/CN.14/245.

[3] E/CN.14/290/Rev.1.

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[1] Now called "the Democratic Republic of the Congo".

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Part I

PROCEEDINGS OF THE CONFERENCE

SUMMARY RECORD OF THE FIRST PLENARY MEETING[1]

Held in the City Hall, Nairobi, Kenya, on Monday, 1 July 1963, at 9.30 a.m.

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Temporary Chairman: **Dr. Te Lou TCHANG, Regional Cartographic Adviser in Africa**

Present:

The representatives[2] of the following countries: Chad, Congo (Leopoldville), Dahomey, Ethiopia, Federation of Rhodesia and Nyasaland, France, Gabon, Ghana, Ivory Coast, Kenya, Liberia, Madagascar, Mali, Morocco, Niger, Nigeria, Senegal, Sierra Leone, Sudan, Tanganyika, Tunisia, Uganda, United Arab Republic, United Kingdom of Great Britain and Northern Ireland, Upper Volta.

Observers from the following countries: Belgium, Canada, Federal Republic of Germany, Israel, Italy, Netherlands, Sweden, Switzerland, Union of Soviet Socialist Republics, United States of America.

Observers from the following organizations: International Civil Aviation Organization, United Nations Educational, Scientific and Cultural Organization, World Meteorological Organization, World Health Organization, International Hydrographic Bureau, Commission for Technical Co-operation in Africa, Association of African Geological Surveys.

Opening of the Conference by the Temporary Chairman

The TEMPORARY CHAIRMAN, speaking on behalf of the Secretary-General of the United Nations, declared the Conference open.

Message from Mr. R.K.A. Gardiner, Executive Secretary of the Economic Commission for Africa

The TEMPORARY CHAIRMAN read the address which Mr. Gardiner would have given if his duties at the Economic and Social Council in Geneva had not prevented him from attending the opening ceremony.

Mr. Gardiner expressed his deep regret at not being able to greet the delegates in person. On behalf of the Economic Commission for Africa he thanked the Government of Kenya, the host Government, for the excellent preparations it had made for the Conference.

Modern cartography had played an important part in many sections of human activities, not only for peacekeeping, economic development and social progress, but even for the needs and enjoyment of everyday life, and the participation of the great majority of African States demonstrated their serious concern that there should be a sufficient provision of maps and other cartographic data to assist them in the fulfilment of their national plans.

The primary objective of the Conference, the first of its kind called by the United Nations for the African continent, was to stimulate and facilitate the execution of practical surveying and mapping so as to assist the various developments projects of the region.

The holding of the Regional Cartographic Conference for Africa in a very early part of the "United Nations Development Decade" had a special significance which gave a more positive meaning to the aims of the Conference. To reach the target contemplated for the Development Decade, careful planning, intensive survey and mass construction would have to be carried out in almost all the major sectors of human activities. In particular, more intensive surveys would have to be planned and executed for the discovery, evaluation and utilization of physical resources to provide new sources of raw materials and energy and new possibilities for agricultural development. Economic advancement of that kind would require modern techniques in order to ensure economy and efficiency, not only in production but also in distribution. This would lead to improvements in the machinery of administration and in the maintenance and operation of completed projects. Urban and rural development, land reform, public health installations and disease control would have to be intensified. Such undertakings presented acute difficulties in the African continent and would involve the use of surveying techniques and, at a certain stage, the making of maps as part of the project.

The Economic Commission for Africa had a special responsibility in promoting economic and social development throughout the continent and in co-ordinating national and international action. The holding of the Conference and the provision of advisers in cartography and related fields to Governments, on request, to study technical assistance projects in that field, constituted a contribution of the Commission towards that purpose.

[1] Provisionally issued as E/CN.14/CART/SR.1.

[2] For a list of representatives and United Nations staff who attended all plenary meetings, see *United Nations Regional Cartographic Conference for Africa*, vol. 1, *Report of the Conference* (Sales No.: 64.I.2), p. 1.

He thanked the Governments of cartographically advanced countries for making available to the Conference their newly-developed methods and the results of their successful experiences. The participation of their experts would be of great help.

The task before the Conference was tremendous and challenging, and the implications of its decisions could be very far-reaching. He wished the Conference every success.

Address by His Excellency Dr. J. G. Kiano, Minister for Commerce and Industry of Kenya

Dr. KIANO said that he was very happy to welcome the distinguished members of the Conference on behalf of the Government, people and the leader and Prime Minister of Kenya, the Honourable Jomo Kenyatta. The Prime Minister was absent from the country, attending a most important Conference in Uganda on the proposed East African Federation, and greatly regretted his inability to be present.

Africa was going through the last phase of the political revolution for total liberation of the motherland. Over thirty African nations already enjoyed their freedom from colonial domination and racial suppression and would soon be joined by their sister countries. Although still actively engaged in this last phase of the revolution for liberation, Africa was also actively engaged in a new revolution, namely, economic revolution. Kenya was determined to effect a dramatic economic revolution that would raise the *per capita* income, the purchasing power and the general standard of living for the whole population at a rate that perhaps might not be termed miraculous but would certainly be gigantic and possibly unparalleled in recent history.

The expansion of communication facilities, and the very assessment of what is feasible in terms of short-term and long-term projects were all vitally dependent on the findings and conclusions of the cartographic experts. One of the main concerns of the Conference would be to assess the needs of Africa in the cartographic sector and the ways and means to meet those needs. Shortage of manpower was Africa's greatest hurdle in the race of progress.

It was of urgent importance to undertake a projection of manpower requirements for Africa in the various branches of service such as cartography, or else the development plans might well end in failure. Means had to be found to utilize the cartographer's skill for accelerating economic growth. Special maps in vast numbers had been produced in Kenya to assist in the ambitious programme of land consolidation and settlements for African farmers. The Survey Department, known as the Survey of Kenya, was producing maps specially intended to meet the needs of a large-scale land re-allocation scheme for the redistribution of some of the land formerly owned in perhaps excessively large single units to a greater number of farmers working intensively on a smaller scale. United Nations irrigation engineers were investigating the possibility of carrying out a large-scale irrigation scheme along the Tana River, Kenya's most important river, and a series of maps was being prepared for that purpose. It was essential for all, irrespective of nationality or faith, to aim at a common target with one purpose and with equal vigour. That target was peace, prosperity and human dignity with freedom and justice. The meeting together in Nairobi of the representatives of so many independent States of Africa to discuss their mutual cartographic needs gave cause to hope that their deliberations would be a new blessing to motherland Africa.

Statements by representatives

Mr. DIAGNE (Senegal), on behalf of African delegations, thanked the United Nations for having organized the Conference and expressed his gratitude to the Government of Kenya for the warm welcome he had received.

Although the map was an instrument of work for all sections of the economy, it was also a means of bringing men together and as such, it was of particular interest to Africans whose prime concern was development and technical co-operation. He hoped, therefore, that the work of the Conference would proceed in a spirit of collaboration and that it would contribute to the economic and scientific growth of the African peoples.

Mr. SIMPSON (Ghana) said that it afforded him very great pleasure to attend the first conference of the United Nations on cartography ever to be held on the continent of Africa, an occasion for which he desired, on behalf of his own and other delegations, to thank the United Nations and the Government of Kenya. It was a unique occasion, in the sense that it emphasized not only the oneness of the great continent of Africa, but also the immense advantages all would gain by working together for the common good. Those who were engaged in the profession of map-making knew too well the impossibility of working in isolation and would appreciate the opportunity afforded by the Conference to meet together to discuss their common difficulties.

Mr. BEN GHACHAME (Tunisia) said that modern life was inconceivable without maps as working documents, which meant mutual help in their preparation. Co-operation of that kind had led to African unity. The Africans were a very courageous people and wanted to know each other better. They had therefore to adapt themselves and think henceforth in terms of the twenty-first century; that would mean the abolition of frontiers and the establishment of large geographical groupings. But there could be no going back to the old ways.

Mr. COKER (Nigeria) said that the peoples of Africa were late starters in the race for progress; but they were yearning to advance and doing everything possible to catch up with those who were ahead. The Conference would give Africans an opportunity to meet together and compare experiences. In some respects Africa offered greater scope for putting this experiment into practice than the already developed areas and the new developments in science and technology would soon bring good results to the continent. He was glad that the Conference was attended by representatives from countries of other continents. Whether as observers or advisers their knowledge would be valuable and he hoped that they would make their advanced knowledge available and impart to Africa the technical knowledge that had allowed their own countries to become so advanced.

Mr. ABDEL HALIM (United Arab Republic) expressed his pleasure at being able to attend the Cartogra-

phic Conference and conveyed to the host country the warm greetings of the Government and people of the United Arab Republic. The Conference would afford Africans an excellent opportunity to pool their experience and overcome their difficulties.

Adoption of the rules of procedure

[Item 1 of the agenda]

The TEMPORARY CHAIRMAN called upon the Conference to consider the rules of procedure. The text of the provisional rules of procedure was to be found in document E/CN.14/CART/3 and Corr.1. They were the standard rules used in the United Nations regional cartographic conferences, adapted to the practice of the Economic Commission for Africa.

Mr. WARREN (Kenya) supported by Mr. SAWYERR (Liberia), moved the adoption of the proposed rules of procedure.

The rules of procedure were adopted.[3]

Election of officers

[Item 2 of the agenda]

The TEMPORARY CHAIRMAN said that according to rule 6 of the rules of procedure, the Conference should elect a President, two Vice-Presidents and a Rapporteur.

Mr. KHALIFA (Sudan) said that it was customary on such occasions to elect the representative of the host Government as President and he would like therefore to nominate the Director of Surveys of Kenya as President. He was confident that all members would support the nomination.

Mr. ABDEL HALIM (United Arab Republic) seconded the nomination.

The TEMPORARY CHAIRMAN said that there was no other nomination and he therefore declared Mr. Warren, the Director of Surveys, Kenya, the duly elected President of the Conference.

He thanked all representatives for their courteous co-operation.

Mr. Warren took the Chair.

The PRESIDENT said that he was deeply conscious of the honour done to the Kenya delegation and himself and assured members he would do everything in his power to make the Conference a success.

His first duty as President of the Conference was to close the first plenary meeting of the Conference.

The meeting rose at 11.40 a.m.

[3] See above.

SUMMARY RECORD OF THE SECOND PLENARY MEETING[1]

Held in the City Hall, Nairobi, Kenya, on Monday, 1 July 1963, at 3.00 p.m.

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President: **Mr. WARREN (Kenya)**

Election of officers *(continued)*

[Item 2 of the agenda]

The PRESIDENT invited the delegates to submit nominations for the offices of First and Second Vice-President and Rapporteur.

Mr. OKEC (Uganda), supported by Mr. SAWYERR (Liberia), Mr. DIAGNE (Senegal) and Mr. HAKAM (Morocco), proposed Mr. Ben Ghachame (Tunisia) as First Vice-President.

Mr. Ben Ghachame (Tunisia) was unanimously elected First Vice-President.

Mr. COKER (Nigeria), supported by Mr. DIAGNE (Senegal), proposed Mr. Simpson (Ghana) as Second Vice-President.

Mr. Simpson (Ghana) was unanimously elected Second Vice-President.

Mr. Diagne (Senegal), nominated by Mr. Agnamey (Dahomey) and supported by Mr. Ben Ghachame (Tunisia), was unanimously elected Rapporteur.

Adoption of the agenda

[Item 4 of the agenda]

The PRESIDENT suggested that the provisional agenda (E/CN.14/CART/1), as drafted, be adopted.

Mr. COKER (Nigeria), supported by Mr. HUMPHRIES (United Kingdom) and Mr. MAMMO (Ethiopia), considered that the agenda should contain a separate item on the training of personnel to follow the item "Development of cartographic services".

It was so agreed.

Mr. COKER (Nigeria), supported by Mr. DIXON (Tanganyika), proposed that the provisional agenda, as amended, be adopted.

It was so agreed.

The provisional agenda, as amended, was unanimously adopted.[2]

Organization of work

[Item 5 of the agenda]

The PRESIDENT suggested that the work of the Conference should be conducted in plenary sessions and by technical committees. He invited the Conference to comment on the suggestion made at an informal meeting of Heads of Delegations that there should be four committees:

Committee I on geodesy and hydrography;
Committee II on photogrammetry;
Committee III on special mapping;
Committee IV on preparation and reproduction of maps.

He considered further that the questions of technical assistance and international co-operation could be dealt with in plenary sessions but, if need should arise and if delegates so wished, a special sub-committee could be formed to study a specific question.

Mr. SAWYERR (Liberia), supported by Mr. AGNAMEY (Dahomey), proposed that the organization of work suggested by the President be adopted.

It was so agreed.

The organization of work suggested by the President was adopted.

Review of cartographic activities in Africa

[Item 6 of the agenda]

The PRESIDENT suggested that delegations report in alphabetical order.

It was so agreed.

Mr. POMMERAUD (Chad) stated that in Chad the preparation of city plans at the scale 1:2,000 and of maps for land allotment had fully occupied the Service topographique et du cadastre. An important task had already been carried out successfully with the help of aerial photographs taken at the scale 1:6,000. No report had been published.

With regard to the basic mapping of the country, which required extensive and costly technical facilities if it was to be carried out efficiently, it had been decided that the task be entrusted, under the arrangements of bilateral technical assistance, to two French establishments. The French Institut géographique national had undertaken the

[1] Provisionally issued as E/CN.14/CART/SR.2.

[2] For the text of the agenda, see *United Nations Regional Cartographic Conference for Africa*, vol. 1, *Report of the Conference* (Sales No.: 64.I.2), p. 5.

topographical maps at the scales of 1:50,000, 1:200,000 and 1:1,000,000 and the Office de la recherche scientifique et technique outre-mer (ORSTOM) the preparation of the topical map at all scales. These two establishments had submitted to the Conference reports on their activities, to which there was nothing to add.

Mr. YOWALOLA (Congo, Leopoldville) drew the attention of members of the Conference to the fact that the Institut géographique national du Congo (Léopoldville) was responsible for preparing all the cartographic documents for the country; a report on general levelling, to be found in document E/CN.14/CART/48, had been submitted to the Conference, as well as a general report on cartographic activities, document E/CN.14/CART/49. With regard to aerial photography, only about one-fifth of the territory remained to be covered.

Mr. AGNAMEY (Dahomey) said that the French Institut géographique national was responsible for all cartographic work in west Africa, including Dahomey.

Mr. MAMMO (Ethiopia) said that at that time his delegation had no comments to make on his country's report, which appeared in document E/CN.14/CART/44.

Mr. DELIENNE (France) pointed out that his delegation had submitted a number of documents on the work of the French Institut géographique national in Africa and Madagascar. The index maps to be attached to those documents (E/CN.14/CART/11, 11/Add.1, Add.2 and Add.3, and E/CN.14/CART/19) would be distributed before the following meeting and members of the Conference would be able to assess the work done over the past ten years in astronomy, precise levelling, aerial photographic coverage, topographical mapping and the like. He would willingly supply further details if members so wished.

Mr. QUIGGIN (Federation of Rhodesia and Nyasaland) said that the mapping in Northern Rhodesia was done by both the Federal Survey Department, Salisbury, Southern Rhodesia, and by the Directorate of Overseas Surveys in London. He was not, therefore, qualified to give a detailed report of the work but trusted that a report from the Federation of Rhodesia and Nyasaland had reached the Conference. If not, he had the last annual report of the Federal Survey Department, Salisbury, and would make it available to those interested.

Mr. DE MASSON D'AUTUME (Gabon) pointed out that in Gabon there was the Service topographique et du cadastre most of whose activities were concerned with large scale urban surveys and to the operation of land allotment. The work had not been published.

With regard to maps at small and medium scales, in particular the base map at 1:200,000, the work was entrusted to the French Institut géographique national and especially to its annex in Brazzaville. A full report on this subject had been presented by the French delegation to the Conference.

Mr. OPARE-ADDO (Ghana) regretted that it had not been possible to circulate his country's report before the meeting; he hoped it would be available for members in the near future.

Mr. GILLES (Ivory Coast) pointed out that hitherto all the cartographic work in the Ivory Coast had been performed by the French Institut géographique national. In 1963 the Institut had taken large scale aerial photographs, and carried out complementary field work for several sheets of planimetric base maps for the new edition of 1:200,000 series which, as a matter of immediate urgency, were compiled from trimetrogon photographs. The Institut géographique de la Côte d'Ivoire was in the process of formation, but it would not be in a position to undertake cartographic work for one or two years.

Mr. LOXTON (Kenya) drew the attention of members to document E/CN.14/CART/4, a report on cartographic work in Kenya. Specimens of Kenya's work would be shown in the Cartographic Exhibition and members would learn more about the country's work when they visited the Survey of Kenya.

Mr. SAWYERR (Liberia) said that Liberia had prepared planimetric maps printed in four colours on the scale 1:125,000 in ten sheets based on aerial photography. Some 97 per cent was compiled from photographs and mosaics at a scale 1:20,000, geographically controlled. The project had started in 1951. The Liberian Cartographic Service had been organized in that year and now possessed its own aircraft and cameras and was taking photographs for topographical mapping. Qualified technicians were available in Liberia but equipment was lacking. If, as a result of the Conference, the United Nations Technical Assistance could devise some means of helping countries to obtain the technical equipment they needed, such as stereo plotters and similar instruments, a great contribution to the development of cartography in Africa would have been made.

Mr. TRAIZET (Madagascar) pointed out that the Malagasy Government had concluded an agreement with the French Institut géographique national whereby the latter was entrusted with the task of providing the Government with geographical, topographical and cartographic data on Madagascar.

The first objective was to cover the whole island with a 1:100,000 scale map which was now well advanced: (*a*) aerial photography at the scale 1:50,000 covered the whole island; (*b*) about 90 per cent of the first-order geodetic work had been completed and the over-all adjustment of the nets was in preparation; (*c*) 330 out of the 450 sheets of the map at 1:100,000 required to cover the whole island had been published.

The French Institut géographique national was equipped to undertake large-scale mapping (1:50,000, 1:20,000, 1:10,000 and 1:5,000) in the regions where the state of economic development required such mapping.

The competence of the French Institut géographique national ended with mapping at the scale 1:5,000. The responsibility for plans at scales larger than this fell on the Service des travaux publics (town planning and housing) and the Service topographique (public land and real estate).

Mr. BAMORY (Mali) remarked that cartographic work in Mali was entrusted to the French Institut géographique national. The Government of Mali had recently established the Institut cartographique national and it was hoped that with the assistance of experts supplied by the French Institut géographique national and the United

Nations Bureau of Technical Assistance Operations, the Institut would soon start operating, thus enabling Mali to become self-sufficient as regards cartography.

Mr. HAKAM (Morocco) said that the Service géographique du Maroc had assumed responsibility for the mapping work previously performed in Morocco by the French Institut géographique national. With the exception of an east-west strip in the extreme south of the country, the geodetic networks had been completed. General first-order levelling links covered the entire territory and these had been double-checked by gravimetric observations. All Morocco was covered by maps of 1:200,000 and there were also maps on the scales of 1:100,000 and 1:50,000. Aerial photographic coverage had been completed and was brought up to date every year in the more important regions. The whole of Morocco was covered by a reconnaissance map on the scale 1:100,000 upon which a map on the scale 1:50,000 was superposed for regions of great economic importance. Standard maps on the scale 1:50,000 were being produced at an ever-increasing rate. Under the general cartographic programme, maps on the scale 1:20,000 to 1:100,000, depending on the region, would be made and all the maps produced conformed to international sheet-line systems. The Moroccan Government was endeavouring to modernize its cartographic equipment and was paying special attention to the training of technical personnel. The main administrative bodies were well aware of the value of mapping and the Government had been obliged to set up a National Cartographic Committee to draw up a rational programme. A general atlas of Morocco was being published[3] and a national photo-library containing all the aerial photographs of Morocco was being formed.

Mr. GOURMENT (Niger) indicated that the general cartographic work in Niger was entrusted to the French Institut géographique national. Aerial photographic coverage at the scale of 1:50,000 had been completed for the whole country and the astronomic control nets for the survey at the scale of 1:200,000 had been measured entirely. Precise levelling over 6,600 km. had been completed. About one half of the country was covered by surveys at the scale 1:200,000. The survey at the scale 1:50,000 had been started.

With regard to large scale surveys (1:2,000, 1:5,000 and 1:20,000) the Service topographique et du cadastre of the Republic of Niger had been entrusted with the preparation of city plans and studies of town planning and the development of interesting regions of the country.

Mr. COKER (Nigeria) explained that due to administrative changes, Nigeria had decided rather late to send a delegate to the Conference and it was not possible to submit a paper on the cartographic activities of Nigeria. The country was a federation of three regions with a federal Government, so there were four different survey organizations, but they worked as a team. Mapping was handled by the regional and federal governments with the federal Government responsible for geodetic surveys and the major part of the topographical survey and the regional governments concentrating on cadastral surveys. The country was covered by a triangulation network which would soon be adjusted under United Kingdom technical assistance. Scale checks with a tellurometer and azimuth checks with the Wild T.4 theodite were being carried out.

Under the six-year development programme the Government had undertaken to have the whole country mapped by 1970 on the scale 1:50,000. The work was being done partly with the assistance of the United Kingdom and Canadian Governments and partly by the Nigerians themselves. The Survey Department had been equipped with modern machines and its staff increased; that would enable the Nigerians to continue the work unaided when the technical assistance provided by outside Governments came to an end. Most of the reproduction work was already performed by the Nigerians themselves.

All the regional governments had large-scale mapping programmes and they were nearly all equipped with photogrammetric plotting machines.

Mr. DIAGNE (Senegal) pointed out that in the west of Senegal, the programme of general cartography at the scale 1:200,000 and 1:500,000 had been completed. The Service topographique of Senegal had prepared plans at large scales for the administrations in charge of public works, town planning, cadastral surveys and agriculture, etc., but the lack of equipment constituted a handicap. The Government was concentrating its efforts on these large scale plans and, with the assistance of the United Nations, was endeavouring to begin to fill the need for equipment of its topographical service and for training technical personnel.

Mr. SKUSE (Sierra Leone) said that the report on his Government's work on cartography had been circulated as conference document E/CN.14/CART/53. Sierra Leone was well aware of the need for mapping but did not have the necessary funds to do all the work required. He thanked the United Kingdom Department of Technical Co-operation for topographical mapping on the scale 1:50,000. It was difficult to find suitable students and to secure the services of training staff. His country did not possess a lithographic printing press but under the development programme one would be acquired as a matter of priority.

Mr. KHALIFA (Sudan) said he had nothing to add to the information contained in documents E/CN.14/CART/42 and E/CN.14/CART/43 submitted by his Government.

Mr. DIXON (Tanganyika) drew the attention of members to document E/CN.14/CART/40, submitted by Tanganyika. A large number of maps had been compiled and printed in Tanganyika, but the country was vast and a big task lay ahead of the Government. Valuable assistance in the preparation of the base 1:50,000 map had been received from the Directorate of Overseas Surveys of the United Kingdom. In Tanganyika priority had been given to training.

Mr. BEN GHACHAME (Tunisia) pointed out that the report of the Service topographique of Tunisia had been distributed as document E/CN.14/CART/46. Cartographic work had been increased and when the infrastructure and superstructure had been completed certain modifications would be introduced.

Mr. OKEC (Uganda) said that all cartographic work in Uganda was performed by the Lands and Surveys Depart-

[3] See a report on this question on p. 115.

ment. The primary triangulation had been completed; the work of breaking down from the primary to the secondary triangulation was in process and was nearly complete. The whole country was covered by air photographs on the scale 1:40,000 and there were also large-scale photographs of all major towns. Precise levelling was being undertaken under the guidance, and with the assistance, of the Directorate of Overseas Surveys of the United Kingdom. Secondary levelling from the fundamental maps established under precise levelling was also being carried out and water gauges around Lake Kyoga and along the Nile were being connected to the primary network.

All major towns were mapped on the scale 1:2,500, which was the basic scale. Two towns had been mapped on the scale 1:10,000 and there were other 1:20,000 maps which had been drawn up to slightly different specifications. Work on the scale 1:50,000 was, for the most part, performed by the Directorate of Overseas Surveys of the United Kingdom. Three maps for tourists had been compiled on the scale 1:125,000, namely, Central Ruwenzori, Murchison Falls National Park and Queen Elizabeth National Park; in the topographical series the whole country had been covered at the scale 1:250,000. There were also soil, geology and vegetation maps at that scale and a topographical map at the scale 1:500,000 had been produced for use in offices and schools.

An effort was being made to publish a new edition of the 1:1 million map which covered the whole country in one sheet. The map was being drawn to the specifications of the *International Map of the World on the Millionth Scale* and was nearly complete. With the help of the other government departments in the country, the *Atlas of Uganda* had been published. The majority of its sheets were at the scale 1:500,000 but there were sheets at smaller scales. All the maps to which he had referred would be seen in the Cartographic Exhibition. More detailed information could be found in his country's report, published in document E/CN.14/CART/41 and Add.1.

Dr. WASSEF (United Arab Republic) said that most delegates would realize that surveying was as old as the civilization of ancient Egypt; a statue showing the standard length of several thousand years ago, was to be seen in the Cairo Museum. His country had never overlooked the importance of cartography and had always developed appropriate techniques. Cartographic work was carried out by the Survey of Egypt, which had been opened in 1898 and by two other establishments, one dealing with military work and the other with hydrographic surveying. He drew the attention of members to four documents, E/CN.14/CART/72 to E/CN.14/CART/75, which contained a review of cartographic activities in Egypt.

The transliteration system was being developed, and the Survey Department also produced atlases and wall maps. Cadastral sheets were produced at the 1:1,000 scale and published at the 1:2,500 scale. The standard scale for town mapping was 1:5,000. Special town maps at the scale 1:2,500 were also produced for planning work and a very large project of producing maps for planning rural development in villages had been embarked upon. The Survey Department made crop surveys three times a year and special air survey techniques for crop surveying had recently been developed. An important soil survey was also being concluded.

Special attention was paid to training. There was a school for the training of field surveyors and no effort was spared to secure well qualified supervisors.

A considerable amount of research work had been done and approximately 120 publications had been issued by the Survey Department.

Mr. HUMPHRIES (United Kingdom) pointed out that document E/CN.14/CART/47 was a report of the United Kingdom's cartographic activities in Africa.

Mr. TIMMER (ICAO) said that his Organization's interest in cartographic conferences was twofold. In the first place, it wished to ensure that due consideration was given to aviation cartography and that action was not taken which would compromise ICAO standards and recommended practices or its cartographic programmes; secondly, it wished to assist in the development of first class cartographic services and basic surveying and mapping programmes which would ultimately benefit civil aviation and the economic progress of countries in general. A description of ICAO's work would be found in document E/CN.14/CART/52 and Add.1.

Vice-Admiral DOS SANTOS FRANCO (International Hydrographic Bureau) explained that the International Hydrographic Bureau was an intergovernmental organization which had been founded in June 1921 and was composed of forty-one member States. It was a purely consultative agency and had no authority over the hydrographic services of member States. Its purpose was to establish a close and permanent association between the hydrographic services of its members; to co-ordinate their work with a view to rendering navigation easier and safer in all seas; to endeavour to obtain uniformity in charts and hydrographic documents; to encourage the adoption of the best methods of carrying out hydrographic surveys; and to encourage improvements in the theory and practice of the science of hydrography.

The General Conference met once every five years and reviewed the work of the Bureau. Resolutions were passed by a majority vote in which each State had one vote; they had no legal binding force and were not formally ratified by the various Governments.

The Bureau produced various publications.

Mr. EVANS (CCTA) drew the attention of members to documents E/CN.14/CART/33 and 36, submitted by the Commission for Technical Co-operation in Africa: the first dealt with his organization's work in cartography and the second with inter-African co-operation in mapping. He said that in the following year there would be a symposium in Tananarive on photogrammetry and mapping.

The PRESIDENT said that he thought all members would want to comment on the delegations' reports. He himself had been struck by four points: first, by the delegate of Liberia's remark that they had the technicians but not the instruments; secondly, by the difficulties faced by Mali in starting its own cartographic department; thirdly, by the efforts being made by Morocco to modernize its department; and lastly by the fact that the United

Arab Republic demanded the highest standards from their supervisory staff.

He asked whether any of the official observers wished to report on the cartographic work of their organizations in Africa.

Miss DELANEY (Association of African Geological Surveys) said that her organization was concerned only with specialized maps on the different disciplines of geology and with maps at scales smaller than 1:2,000,000. They had started publishing a geological map of Africa at the scale 1:5,000,000, which would be ready for printing in December. The future programme of the Association included a tectonic map of the whole of Africa at the scale 1:5,000,000 and a mineral map at the scale 1:5,000,000; both were being published with the help of UNESCO.

Submission of credentials

The PRESIDENT reminded all delegates that credentials should be submitted to the Executive Secretary of the Conference without delay.

The meeting rose at 4 p.m.

SUMMARY RECORD OF THE THIRD PLENARY MEETING[1]

Held in the City Hall, Nairobi, Kenya, on Tuesday, 2 July 1963, at 9.45 a.m.

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President: **Mr. WARREN (Kenya)**

Development of cartographic services

[Item 7 of the agenda]

The PRESIDENT invited the Conference to consider item 7 of the agenda: development of cartographic services.

Mr. GILLES (Ivory Coast) said that his Government intended to create a national geographical institute. This institut géographique de la Côte-d'Ivoire would have to be created out of nothing and the great difficulty to be solved was, of course, financial. The Government therefore hoped that the programme could be extended over a period of several years. The first plan, which was to be spaced out over three years, had not been maintained, owing to the difficulty encountered in providing the necessary annual appropriation of 100 million CFA francs. It had therefore been necessary to draft a second plan, the implementation of which was due to begin shortly. This revised project would be carried out in three stages, in accordance with the credits available every year; stage 1: construction of a technical building to house the photogrammetric section and the drawing office; stage 2: equipment of the premises and installation of storehouse for the apparatus and maps; stage 3: installation of an offset printing plant and a photogravure shop. If need should arise, the work of stage 3 might be postponed. The situation was as follows: building plans were complete, the Government had allotted a building site at Abidjan and appropriations amounted to 50 million CFA francs. It was therefore hoped that the building could be erected during 1964.

There was one other difficulty; the training of staff, which could be solved thanks to the assistance of the French Institut géographique national. During 1960 and 1961, twelve students had been sent to the École des sciences géographiques in Paris and should obtain their engineering certificates by the end of the year. The training of the subordinate staff would take place on the spot, in Abidjan, and the first contingent would be ready within a year.

The Ivory Coast possessed a temporary geographical office, well-equipped but on a modest scale, comprising an information service, a drawing office and a workshop for the processing of aerial photographs. In 1962, moreover, a Geographical Institute Directorate had been established in the Ministry of Public Works.

The institut géographique de la Côte-d'Ivoire would soon be a reality, even if completion of the work of the third stage had to be further postponed. In the meantime, the country would be able to count on the assistance of the Institut géographique national, whom the institut géographique de la Côte-d'Ivoire would in any case have to relieve of its present task. This task would consist of preparing sheets at the scale 1:200,000—completing the series and keeping them up to date—and of publishing new maps of the Ivory Coast at the scale of 1:100,000 and at larger scales.

In fact the country did not yet possess the elements of a fundamental geodetic survey, but the Government had decided to establish a new cadastre. That was a difficult and costly task: the first order network of a 10,000 km. polygon would cost about 2 million United States dollars. It would take fifty years for the country to carry out alone and unaided a polygonation of the entire Ivory Coast national territory, but fifteen years with outside help. The matter had recently been broached with the United Nations Mission in Abidjan.

Mr. DIAGNE (Senegal) indicated that Senegal was now concerned with the reorganization of its Service topographique, which dated back to 1907. After giving a brief description of the Service, he pointed out that Senegal was a flat country and even the means at the disposal of the United Nations would be insufficient to provide a geodetic base for the whole national territory. At first one would have to be content with a map at the scale of 1:10,000 or of 1:15,000.

He asked whether it would not be better for Africa to deal first of all with the question of training rather than with cartographic programmes, the implementation of which were always very costly. The Government of Senegal had decided to re-model its present service and to entrust to the Institut géographique national the training of the necessary staff at higher levels. Senegal would not take over the heavy task of the Institut géographique national until its Service topographique possessed the adequate technical staff.

Mr. AGNAMEY (Dahomey) recalled that the first cartographic work performed in Dahomey had been carried out by the army in 1894; later a topographical service had been established in French West Africa in 1907 and finally, since independence, the Dahomian section of that service had been set up as a national service forming part of the Ministry of Public Works and Transport. That

[1] Provisionally issued as E/CN.14/CART/SR.3.

service was about to be reorganized and would progressively take over the work from the French Institut géographique national. It already had a competent staff but the equipment was lacking. In addition to an administrative directorate it consisted of three divisions each directed by an engineer: (1) the Land and Cadastre Division, which was divided into six sub-divisions (one for each administrative department), was responsible for large-scale surveys; (2) the General Works Division, also composed of several sub-divisions, carried out rural engineering studies and prepared urban development projects; (3) the Cartographic Division, which consisted of one sub-division for geodesy and triangulation and one for photogrammetry (stereopreparation and plotting). The activities of the last division were still limited; plotting, for example, was still carried out by French undertakings and the photographs were processed by the French Institut géographique national. The Service did not yet possess a printing plant and printing, too, was entrusted to the Institut géographique national. The present staff, which was entirely African, consisted of six engineers, twenty-six surveyors and technical assistants, eight operators, five draughtsmen and twenty assistant draughtsmen.

Mr. BONNET-DUPEYRON (France) pointed out that he belonged mainly to the Office de la recherche scientifique et technique d'outre-mer (ORSTOM). That organization, whose activities were described in documents E/CN.14/CART/22 and 24, was a topical cartographic service, a fact which accounted for its originality. The staff of ORSTOM consisted of research workers who worked in such varied branches as law, hydrography, oceanography, human sciences, geophysics and the like. The whole staff, although dispersed mainly in Africa and Madagascar, worked in close collaboration, so true was it that the difficulties facing developing countries could not be considered in isolation. The assistance of a great number of specialists was essential.

Since its institution, ORSTOM had published 430 topical maps at all scales, some of which could be seen in the Exhibition on the stands of the various countries in which they had been compiled.

He stressed the fact that if scientific research had often to forget the existence of frontiers, topical cartography ought also to cover whole regions even if, for financial reasons, this was not possible in the beginning.

Mr. WASSEF (United Arab Republic) did not think it was necessary for the cartographic services of developing countries to be designed on the same lines as those of advanced countries. Account should first be taken of the real needs of the countries and then the simplest methods could be chosen. The establisment of a cadastre was one of the prior needs. That operation should, of course, be conducted from the beginning with the greatest possible precision, but a cadastre that was less precise than normal was better than no cadastre at all. Egypt provided an example of that: in 1898, the establishment of a cadastre had become a necessity. Unfortunately, at that time there had not been a sufficient geodetic basis to allow very great precision and the plans which had then been compiled over a period of some ten years and which related solely to the region covered with vegetation were not free from imperfections. Nevertheless, it had been possible to attain the objective within a very short time. Since then the methods used had been perfected and a new cadastre had been embarked upon. A developing country which wished to establish a cadastre quickly could resort to photography to establish first a reconnaissance map and then gradually improve the precision from new photographic documents. In consequence, it would be suitable to define there and then the minimum precision permissible for that type of work and then seek the simplest methods which were the most appropriate for developing countries.

The meeting rose at 11 a.m.

SUMMARY RECORD OF THE FOURTH PLENARY MEETING[1]

Held in the City Hall, Nairobi, Kenya, on Tuesday, 2 July 1963, at 2.30 p.m.

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President: **Mr. WARREN (Kenya)**

Development of cartographic services *(concluded)*

[Item 7 of the agenda]

The PRESIDENT invited members to continue their discussion of item 7 of the agenda: development of cartographic services.

Mr. WHITTAKER (Uganda) drew the attention of members to the word "development" in the title of the item. Development could be regarded as a ladder of progress, the foot of the ladder being the building up of a cartographic service from nothing and its top being unattainable because the cartographic services of a country could never be perfected.

Uganda had advanced some distance up the ladder. The Department of Land and surveys, which had been formed in 1900 mainly to carry out cadastral surveys for title purposes, was responsible for the cartographic service. There were 120,000 registered titles in Uganda. Development lay in increasing the number of properties on the register and, as the representative of the United Arab Republic had suggested, possibly in the greater use of photogrammetry. One of the factors limiting the use of photogrammetry in Uganda, however, was the density of the vegetation to be covered.

Most of the maps produced in Uganda dated from 1951 when the reproduction plant had been installed. The basic urban scale was 1:2,500 and the basic topographical scale 1:50,000. The urban scale showed all detail appropriate at that scale and carried a good overprint showing urban plots. It was virtually complete in the first edition for the whole country. Over half the country had been covered on the topographical scale and it was expected that by the end of the year two-thirds of the country would have been covered. Other scales were being compiled from the two basic scales. A 1:500,000 wall map had been produced and the sheets of the *International Map of the World on the Millionth Scale* were nearing completion. Attention was being turned to special purpose maps and soil, vegetation and geology maps on the scale 1:250,000 had been published. An atlas had been compiled containing several maps and surveys on the incidence of malaria, tsetse species and so on.

As far as Uganda was concerned, therefore, development consisted in the production of more special purpose maps, maps for tourists and so on, the maintenance of existing surveys, the completion of surveys already well advanced and the further use of those series to develop special types of maps.

Mr. SIMPSON (Ghana) said that surveying and mapping in Ghana had started in 1922 when the south-east of the country had been covered with a very adequate triangulation system. To the south-west, where the land was relatively flat and thickly forested, it had only been possible to build up a system of controls by precise traverses. Further north the land was also fairly flat but as is was covered with a savannah type of vegetation, precise traversing was again the best means of establishing controls. By 1945, practically the whole of Ghana had been covered with adequate planimetric geodetic control.

Very little, however, had been done for vertical control. Most of the triangulations observed vertical heights but they were only suitable for topographical mapping, which advanced side by side with the triangulation and precise traversing. Upon the outbreak of war, the mapping of Southern Ghana up to latitude 7°30 north with 1:62,000 topographical maps had been completed. Further north it had only been possible to cover the whole territory with 1:250,000 and 1:125,000 military or other rapid surveys.

Due to the shortage of professional staff in the years following the war, the level of topographical and geodetic work had declined until it had become necessary to develop the Volta basin for electric power. The Directorate of Overseas Surveys of the United Kingdom had assisted in the mapping of the Volta basin and had helped to produce the 1:50,000 map specifically for the Volta River project. Topographical mapping using modern photogrammetric methods had been resuscitated; and one-quarter of Ghana had been covered with suitable planimetric height control.

Under the future programme these controls would be extended to enable one half of Ghana north of latitude 7°30 to be covered with 1:50,000 maps. Ghana's level controls had been extremely sparse but a scheme had just been produced whereby level controls covering the whole country were expected to be completed within the following four of five years. The biggest handicap was the lack of professional staff. A large number of Ghanaians had received basic training but could not complete their professional training because of a lack of experienced staff. Another difficulty was that shortage of personnel made it impossible to release staff-members for advanced training

[1] Provisionally issued as E/CN.14/CART/SR.4.

courses. At the same time, various government departments submitted requests for development surveys, particularly for hydroelectric power development, industries such as iron ore development and the like.

Ghana was keenly interested to know what assistance it could expect from organizations like the United Nations.

Mr. DELIENNE (France) said that until recently little cartographic work had been done in Africa and that countries had met their most pressing needs by compiling general maps of their territories. That first step had enabled Governments to improve the economy of their countries, establish communication systems and the like. Nowadays States had to face new problems and new maps of greater accuracy were needed. In the first place, States should prepare an inventory of their needs because any error in their estimates could lead to considerable expense. The over-all programme should also take account of the logical sequence of work to be carried out, the best possible scales to be used and the time limits to be set. Each State, therefore, should set up a national mapping committee on which the various interested departments would be represented. The task of those committees would be to draw up the inventory he had mentioned and make recommendations to the appropriate minister.

Mr. YOWALOLA (Congo (Leopoldville)) suggested that, in order to save time, delegations should submit descriptions of the organization of the cartographic services of their countries as documents.

Mr. COKER (Nigeria) said that before and immediately after the war Nigeria's Cartographic Service had been of a high standard and in a position to fulfil all the tasks expected of it. Unfortunately, that service had been allowed to decline into little more than a cadastral service and the Government was currently faced with the task of re-organization. He questioned the wisdom of the developing countries which were trying to adopt the mechanical mapping systems followed in the advanced countries merely for mechanization's sake. Where labour was plentiful and inexpensive it might be more economical to train men to do the work than to spend money on costly equipment. Such a step might help to relieve the unemployment situation of some countries. He did not mean that modern methods were to be abandoned but that, before deciding on full mechanization, developing countries should examine their resources backgrounds and needs.

Mr. SKUSE (Sierra Leone) said that the Surveys and Lands Department of Sierro Leone had been founded in 1927 for topographical mapping. Over the past decade it had been engaged in the preparation of large-scale maps for the acquisition and leasing of land.

He agreed with the representative of France that national committees should be set up to channel requests for technical assistance to such organizations as the United Nations and to act as a shorting house for information and reports from other countries.

Mr. BEN GHACHAME (Tunisia) said that the Topographical Service of Tunisia had been in existence since 1886. The legal experts were of the opinion that the service should apply the provisions of the 1885 Land Act relating to the registration of Land. Its activities had been limited to that field until Tunisia's accession to independence in 1956. Since then the cartographic services also formed part of the Topographical Service.

Mr. SAWYERR (Liberia) said that in developing its cartographic service a country had to consider the type of work for which that service was intended. It was essential to have planimetric and topographical maps on which cadastral features could be superimposed.

It was advisable that each country should establish a national cartographic section organized in such a way as to ensure maximum efficiency. The services should consist of three sections: (*a*) planning, data collection and examination, production and actualization; (*b*) reproduction and dissemination; (*c*) correlation and application.

Section (*a*) would be concerned with collecting and grading existing data and acquiring further information by the application of techniques in geodesy, aerial photography, photogrammetry, hydrography, cartography and field checking. It was essential that the administrative service of that section should be as efficient as the purely technical services so as to be of assistance in evaluating time and motion studies to enable production to meet deadlines.

Section (*b*) would be responsible for preparing photostats, enlargements, blue prints and offset prints. Dissemination of data and information could be effected through direct co-ordination with the users or through sales agencies and advertisements in engineering journals.

Correlation and co-ordination between the geodetic and cartographic service and all organizations likely to use the facilities provided by that service or to contribute pertinent data on geodesy and cartography would be effected under section (*c*).

One branch of the national cartographic service would have to be devoted to demonstrating the best possible application of maps in each phase of economic development.

He stressed that an important handicap in the establishment of national cartographic services was the reluctance of Governments to provide adequate funds and recognize the need for a national cartographic service to provide base maps on which specific projects would be planned.

Mr. DIAGNE (Senegal) endorsed the remarks made by the representative of Liberia and suggested that the Conference should adopt a resolution recommending the establishment of national mapping committees and inviting countries to pay special attention to the organization of cartographic services.

Mr. MAMMO (Ethiopia) said that his Government had organized a single service to compile the maps needed by the various governmental departments. An institute had started operating in March 1954 as a small service in the Ministry of Education, primarily to supply topical maps and text books on geography. Later it had been enlarged, re-organized and placed under the Ministry of the Interior. As it had been unable at first to supply the mapping needs of all government departments, ministries had started organizing their own cartographic units. To obviate duplication of services, equipment and personnel, however, the Government had recently forbidden the various ministries to organize individual cartographic units and had decreed that all existing units were to be re-organized

under the Imperial Ethiopian Mapping and Geographic Institute.

Under a special co-operative aid agreement concluded with the Government of the United States, a very large projects of aerial photography and geodetic surveying would shortly be started.

Under a previous agreement with the United States, the Blue Nile river basin area had been covered with aerial photography on the scale 1:50,000, together with a first-order triangulation network.

For road planning purposes certain parts of the Empire had been covered with aerial photographs on the scale 1:20,000 and, with the aid of the United Nations Special Fund, the Awash river valley basin had been covered on the scale 1:40,000.

Mr. TRAIZET (Madagascar) said that the general cartography in Madagascar had reached a very advanced stage. Three-quarters of the territory was covered by maps on the scale 1:100,000 and the remaining quarter by pre-maps on the same scale containing planimetric features only obtained from 1:50,000 aerial photographs which already covered the whole island. The task facing Madagascar was to devise means whereby the greater part of its financial resources could be devoted to large-scale mapping, an indispensable preliminary to any development plan. The Mapping Committee had therefore, in liaison with all the services concerned, drawn up an inventory of requirements. The Committee met periodically to study the needs of the various services, assess the cost of the contemplated operations and, in collaboration with the General Planning Board, establish an order of priority. Madagascar's ten-year development plan would be definitely decided upon very shortly and it seemed that, provided funds were available, the country's cartographic requirements could be met. So far, funds had been supplied by the French Government, the Fonds d'aide et de coopération and the Fonds européen de développement d'outre-mer.

The PRESIDENT said that it was clear from the discussion that the departments of countries attending this Conference were at such different stages of development that no one resolution could possibly cover them all. Nevertheless, four resolutions might well be drafted, on: (1) the advisability of establishing national mapping committees; (2) the need for Governments to allocate sufficient funds for cartography with the help, perhaps, of the United Nations; (3) the necessity for countries to assess their needs very carefully and perhaps employ their surplus manpower rather than costly mechanical equipment; and (4) the advisability of setting up a single cartographic service to supply all the requirements of a country and thus avoid waste.

Training of personnel

[Item 8 of the agenda]

The PRESIDENT invited the Conference to turn to item 8 of the agenda: training of personnel.

Mr. KHALIFA (Sudan) stressed the necessity of accurate, large topographical plans for African development programmes. Most African countries were experiencing difficulties in recruiting suitable professional staff to carry out extensive cartographic programmes, and unless the United Nations paid special attention to that matter the economic development schemes of most countries would have to be shelved for many years. His Government suggested that the United Nations should establish a cartographic training centre for Africans to provide training in all branches of cartography in its widest sense. His Government also suggested the establishment of an electronic computing centre to train Africans to make the various computations relating to survey and other engineering works. Such computations were at that time made outside Africa.

Mr. HAKAN (Morocco) said that the training of personnel was of vital importance. It was desirable that, under its technical assistance programme, the United Nations should pay more attention to the training of supervisory staff. In Rabat there was a Higher School of Engineering which consisted of four departments: mining, public works, mechanical and electrical engineering and topographical engineering. He suggested that the United Nations should supply the school with technical assistance in the form of equipment and, above all, send competent professors to train engineers for those African States which needed them.

Mr. DIAGNE (Senegal) said that he did not fully agree with the Moroccan representative's suggestion regarding staff training. The staff in Senegal had had sufficient basic training; what they lacked was training in modern techniques. Such training could be provided by an African centre for advanced courses.

Mr. OKEC (Uganda) said that as his Government had been unable to afford to send staff abroad for technical training it had decided to raise the standard of existing staff members by making them pass a series of progressively difficult examinations. Officers from abroad had arranged evening classes which the local draughtsmen had attended voluntarily and at which they had been taught the theory of cartography to complete practical training they were given during their normal day's occupation. At the end of a course of evening classes students had had to pass theoretical and practical examinations and if successful in both, were promoted to a higher grade. The system had undoubtedly been successful in raising the standard of local draughtsmen. He recommended, therefore, that rather than looking for external assistance in the training of technicians, poor countries should make use of available resources.

Mr. COKER (Nigeria) paid a tribute to the author of the paper submitted by Kenya entitled the development of surveying and photogrammetry as a university discipline in East Africa (E/CN.14/CART/31). He agreed with many of the opinions expressed therein but did not share the view that only graduates with poor results seemed to drift towards surveying. Graduates were available but the services had to know how to recruit them. Universities should be encouraged to provide courses on surveying and more attention should be paid to the training of cartographers. He wondered if there was a single institution in the world which was really training cartographers. The prevailing system of on-the-job and makeshift training was unsatisfactory. The Conference should adopt a resolution recommending the United Nations or

some other appropriate agency, to establish an institution for the proper training of cartographers.

Mr. HUMPHRIES (United Kingdom) said that in his opinion, training was a local question which should be taken up locally and done locally. In the higher professional grades the tendency was to go for university training. He agreed with that but did not agree with the survey degree. He would much rather see a man earn university training, get his all-round education and go on and do his advanced survey training afterwards. There was not yet much chance in Africa of that further training in surveying, but it should be developed because it was wrong to rely entirely on outside agencies. If at all possible, the training of technical grades should be given in the country concerned, and if facilities were not available they should be built up as soon as possible. It might be found necessary to send one or two of the better men for training overseas or in other countries so that they came back with new ideas and acted as a levelling in their own departments. However, training should be provided locally and not by a regional school or centre.

Mr. YOWALOLA (Congo (Leopoldville)) said that the Institut géographique du Congo had highly-qualified engineers at its disposal and could make available to African countries precision instruments used in various parts of the world.

The meeting rose at 4 p.m.

SUMMARY RECORD OF THE FIFTH PLENARY MEETING[1]

Held in the City Hall, Nairobi, Kenya, on Wednesday, 3 July 1963, at 2.40 p.m.

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President: **Mr. WARREN (Kenya)**

Training of personnel *(concluded)*
[Item 8 of the agenda]

The PRESIDENT invited members to continue their discussion of item 8 of the agenda, training of personnel.

Mr. KHALIFA (Sudan) said he wished to clarify the statement he had made at the previous meeting, as he thought it might have given rise to misunderstanding. Although there were training schools in many African countries, including his own, Africa was still largely dependent on foreign schools, particularly for the training of higher grade staff. He appealed to members of the Conference to support the proposal for a United Nations training centre for Africa.

Mr. SAWYERR (Liberia), suggested that the representative of Sudan should submit a formal resolution on the subject. Such a resolution, pointing out the need to encourage young people to seize opportunities for higher education, should counter the suggestion that trainees for national cartographic services did not require university education. The first essential was to attract suitable students, which might be done by: encouraging an interest in geography in schools and other educational institutions; arranging campaigns extolling cartography as a profession; setting up national societies of professional cartographers; providing facilities for preliminary training in local offices and arranging for suitable trainees to be sent to university; and, by encouraging students to take a pride in their heritage. A United Nations cartographic institute should be multilingual, non-sectarian and free from prejudice of any kind.

Mr. SANOGO BAMORY (Mali) pointed out that since 1941 there had been a Public Works School at Bamako which provided training for surveyors. A purely cartographic section had not been established until 1962. A school for first grade engineers, including sections on topography and cartography, would be opened in the following October. Meanwhile, staff was being trained at the National School of Geographic Sciences in Paris. Four young persons from Mali were studying to be engineers in surveying and ten were receiving accelerated training, to be assistant cartographers, plotting machine operators, control plotting technicians, draughtsmen and so on. It was reasonable to suppose, therefore, that Mali would soon possess the staff necessary for the operation of a national cartographic service.

Mr. WASSEF (United Arab Republic) said that the real difficulty was higher level training. Most countries had their own ordinary level training centres, but the question of advanced training required very careful thought before specific proposals for a United Nations centre could be advanced.

Mr. SKUSE (Sierra Leone) endorsed the comments of the United Arab Republic representative, and agreed with the representative of the United Kingdom that the training of lower grade staff was more satisfactory and economical if given locally. To be effective, however, such training had to be continuous. Because of the small numbers involved, senior staff in his country were sent abroad for training. He suggested, therefore, that it might be better to start with local training and later consider the possibility of establishing one or more regional centres depending upon national requirements and the money and trainees available.

The memorandum on staff naming submitted by the French delegation (E/CN.14/CART/27) was particularly interesting.

Mr. DICKSON (Tanganyika) said that junior technical staff had been very successfully trained in his country but recruitment difficulties indicated against the training of professional or scientific staff. It was hoped that the degree course proposed by the University of East Africa would encourage young men of ability to make more interest in the geodetic and cartographic sciences. The syllabus required careful attention. A survey degree might be too specialized but post-graduate study was so specialized that the student might lose some of the basic skills. It would seem reasonable to suppose that general and specialized subjects could be developed side by side.

An important point to be decided was the number of graduates needed, which might be smaller than supposed. The real requirement was senior technicians in large numbers, and in many instances graduates were being incorrectly used.

In general, therefore, Tanganyika welcomed the proposals of the University of East Africa which would, no doubt, result in suitable training being provided for countries outside East Africa.

Mr. WILLIAMS (Kenya) said that he strongly supported the views of the representative of the United Arab Republic. The Conference was concerned with the imme-

[1] Provisionally issued as E/CN.14/CART/SR.5.

diate problems of the developing countries but should not lose sight of the fact that once those immediate problems had been solved it was of the utmost importance that the geodetic sciences should be laid on a firm foundation.

Many African countries, including Kenya, had their own training centres for the sub-professional levels and made use of the specialized staff provided by international institutes. The difficulty arose in connexion with the specialized man who could take charge of survey activities. The University of East Africa was offering a course which would be suitable for the training of such persons.

There was wisdom in the recommendation that the United Nations should sponsor a training centre to serve Africa, but such a centre might duplicate existing services. Before taking any precipitate decision, therefore, the Conference should examine the facilities already available in Africa for the training of all levels of surveyors.

Mr. BEN GHACHAME (Tunisia) considered that countries should play an active part in training their own staff rather than relying solely on the United Nations. In that respect he shared the views expressed by the representative of the United Kingdom. In Tunisia there was a school for the vocational training of students leaving technical schools with the intention of serving as technical officers in the various regions of the country. Upon completion of their studies, those students were appointed as trainees in the various services for one year. In addition to local training, Tunisia continued sending student engineers abroad, particularly to the Saint-Mandé School, a branch of the French Institut géographique national, to the Polytechnic School at Zurich and the International Training Centre of Photogrammetry at Delft. The Tunisian Government also provided refresher courses for officials already in service. For the past three years, technicians of the Tunisian Topographical Service had attended the various workshops of the French Institut géographique national in order to learn modern techniques of reproduction and printing. Latterly the Bureau of Technical Assistance Operations of the United Nations had provided the Tunisian Government with fellowships for advanced training and with cartographic experts. The Swiss and German firms, Wild and Man, had also offered fellowships to enable Tunisian technicians to improve their knowledge of the assembly and maintenance of instruments and machines used in cartographic work.

Mr. VAN DER WEELE (Observer, Netherlands), speaking at the invitation of the President, said that every cartographic or surveying department needed three types of personnel: technicians, superintendents or chiefs of branches or districts, and specialists. The technicians should be trained locally; the training of the superintendents, which should preferably be to the level of a geodetic engineer, might be provided by technical universities serving more than one country; and specialists should be sent abroad to institutes equipped with the very expensive instruments needed for their training.

Mr. EVANS (Observer, CCTA), speaking at the invitation of the President, said that his organization was very concerned with the training of middle-grade personnel and had set up four regional committees to deal with the matter as far as the twenty-four African Governments constituting CCTA were concerned. The discussions in the recent meeting of the CCTA Committee for the Eastern and Central Regions permitted the assumption that the east African countries, Northern and Southern Rhodesia and Nyasaland only required a few new regional training scheme and that national training centres which could offer places to students from other countries would largely satisfy demands for middle-grade training. Middle-grade training in cartography was not mentioned at the meeting as a requirement for new regional training centre.

The members of CCTA had insisted that middle-grade training should as far as possible be given in Africa and in the conditions in which the persons concerned would be working.

Mr. WHITTAKER (Uganda) said he had understood from the discussions at the meeting of the Committee for the Eastern and Central Regions that CCTA did not possess sufficient funds to set up new training centres and would therefore have to rely on existing territorial training centres combined into a regional centre. His country would not be interested in an arrangement of that kind.

Mr. EVANS (Observer, CCTA), speaking at the invitation of the President, said that although his organization had little money available for immediate practical use, it might have access to other sources. At a meeting with members of donor countries and organizations held in Paris in September 1962, CCTA had been asked to prepare a series of projects, indicating their importance and giving details of financial and training requirements, so that the bodies concerned could examine the matter and decide if they would support any of the projects.

Mr. KHALIFA (Sudan), replying to a question from the representative of Ethiopia, said that the centre he proposed would provide higher training for professional surveyors capable of assuming the tasks now performed by foreign technicians.

Mr. MAMMO (Ethiopia) suggested that there should be two kinds of training: local training for lower level technicians, possibly with assistance from the United Nations or from friendly States; and training by means of fellowships from the United Nations or from countries willing to offer them for higher level technicians.

Mr. HUMPHRIES (United Kingdom) recalled that, despite the difficulties raised by various representatives, the Third United Nations Regional Cartographic Conference for Asia and the Far East held in 1961 had adopted a resolution calling for a regional training centre. He enquired if any action had been taken on the resolution.

The EXECUTIVE SECRETARY said that many countries in that region were interested in a regional training centre for specialized subjects, and certain countries stated they were ready to house such a centre; but no agreement on the site had been reached. On the other hand, in order to give potential host countries an idea of the amount of work and financial support involved, the Economic Commission for Asia and the Far East had organized, in co-operation with the Bureau of Technical Assistance Operations of the United Nations, a very successful pilot course in Tokyo on photo-interpretation and airborne geophysical surveying. The matter would no doubt be discussed again at the next regional cartographic conference for Asia and the Far East scheduled for 1964.

Mr. DIAGNE (Senegal) considered that the time factor should also be taken into account in any discussion on the training of personnel. Such training comprised three stages: the basic, or lower training, stage; the middle stage; and the higher training stage. There were two possible ways of dealing with the question of staff training. The first consisted in establishing regional advanced training centres and the second in sending surveyors and engineers to continue their higher training abroad. The latter was the more expensive, but Africa could not wait too long before putting its development programme into practice.

The PRESIDENT summarized the discussion on item 8 of the agenda.

On higher or professional training, a definite proposal had been made, and supported, that there should be a new regional training centre in cartography. Three factors had, however, led representatives to wonder whether it might not be possible to make use of existing facilities: the representative of Senegal had stressed the importance of timing; the Economic Commission for Asia and the Far East had made no progress beyond organizing a pilot course; and the United Arab Republic representative considered that it would be premature to consider a definite resolution on the subject.

There were four suggestions before the Conference. First, the French delegation had submitted a paper pointing out that all the necessary facilities were available in France for the French-speaking countries. Secondly, the representative of Morocco had suggested that the central high school for engineers in Morocco might be developed into a training establishment for engineers of higher qualified staff, possibly with United Nations aid; thirdly, the delegation of Kenya had submitted a paper pointing out the facilities for professional training available at the University of East Africa; and fourthly, the representative of Nigeria had drawn attention to the need for training cartographers as well as surveyors.

Most countries had their own facilities for technical training but there might be a case for combining some of them—for example, under the forthcoming East African Federation.

He invited comments on the question whether it would be better to have an entirely new centre or to make use of existing facilities.

Mr. GOKER (Nigeria) thought it would be better to make use of existing facilities for the time being: in his own country, for example, there was a survey school which provided technological training up to the sub-professional level, at which English-speaking candidates would be welcome. Many matters, such as the question of language and recruitment of the necessary staff, had to be settled before a final decision could be taken.

Mr. SIMPSON (Ghana) said that his country experienced no difficulty in technical training, which was provided by the Cartographic Institute. The difficulty lay in the provision of professional or university training. Efforts to establish courses at the universities were hampered by the lack of competent lecturers in subjects like geodesy, photogrammetry and mapping; and he believed that other countries had similar difficulties. The United Nations could provide valuable help, either by finding university staff or by so reorganizing university training that it was concentrated in two or three universities instead of being provided by a large number of scattered universities.

Mr. DIAGNE (Senegal) considered that before deciding to establish an African centre, members would have to know what means were available and how much the countries and the United Nations would contribute. There were advanced training centres in nearly all African countries. A polytechnic would open in Senegal the following October.

Mr. YOWALOLA (Congo (Leopoldville)) endorsed the statement of the representative of Senegal and emphasized the need for supplementing theoretical work by practical courses.

The PRESIDENT, in the absence of further comment, said that the Executive Secretary would be requested to prepare a draft resolution for consideration by the plenary meeting, taking into account the views expressed during the discussions.

Technical assistance

[Item 9 of the agenda]

The PRESIDENT invited representatives to consider item 9 of the agenda and drew attention to the paper submitted by France, and entilted: Assistance given by the French Cadastral Survey Department to African States (E/CN.14/CART/15).

Mr. SAWYERR (Liberia) reminded representatives that at the previous meeting he had referred to the need to obtain more technical assistance for setting up cartographic services. Vital forms of aid were the provision of advisers and of long-term loans for the purchase of instruments.

Mr. COKER (Nigeria) emphasized that the aim of technical assistance was to help the developing countries to stand on their own feet, and that the Conference should consider how that aim could best be achieved. The kind of aid required was the supply of equipment with expert staff to train people to use it. He suggested that the Conference should examine the technical assistance possibilities offered by the United Nations, other agencies and individual countries; and adopt a resolution requesting United Nations aid for Africa's cartographical needs.

The EXECUTIVE SECRETARY explained that there were two main sources to assistance; the United Nations Regular and Expanded Programmes of Technical Assistance and the United Nations Special Fund. The United Nations Technical Assistance Programme was administered by the Bureau of Technical Assistance Operations (BTAO) whose policy was decided by the Technical Assistance Committee (TAC) which was composed of representatives of member States of the United Nations and of the specialized agencies. Under this programme there were three forms of assistance: the supply of experts to help Governments in planning and carrying out their technical programmes; the granting of fellowships and scholarships for study abroad; and the supply of vital equipment for training purposes. Under OPEX programme, experts could be provided for executive work.

The Special Fund was available to help Governments with pre-investment surveys.

Requests for assistance in either of the above cases had to be made by the Government concerned through the resident representative of the Technical Assistance Board in the country.

Mr. COKER (Nigeria), enquired in view of the Executive Secretary's explanation, what the Conference was to discuss.

The EXECUTIVE SECRETARY replied that the item has been placed on the agenda at the suggestion of a member Government of the Economic Commission for Africa, but no paper had been received.

The PRESIDENT said that the Executive Secretary had given the Conference much food for thought, it was clear that problems of interest to one particular country only could not be discussed. He reminded the Conference of the paper submitted by France he mentioned in the beginning of the consideration of the items and suggested that discussion be deferred until the following meeting.

The meeting rose at 4.05 p.m.

SUMMARY RECORD OF THE SIXTH PLENARY MEETING[1]

Held in the City Hall, Nairobi, Kenya, on Thursday 4 July 1963, at 2.30 p.m.

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President: **Mr. WARREN (Kenya)**

Technical assistance *(concluded)*

[Item 9 of the agenda]

The PRESIDENT summarized the account given by the Executive Secretary at the previous meeting of the forms of technical assistance provided by the United Nations. The Bureau of Technical Assistance Operations (BTAO) supplied experts, granted scholarships, provided equipment for training purposes and, in other circumstances, sent executives under OPEX programme. In addition, assistance in pre-investment surveys could be obtained from the United Nations Special Fund.

Mr. YOWALOLA (Congo (Leopoldville)) said that his country attached great importance to United Nations technical assistance. The Institut géographique du Congo (Geographic Institute of the Congo) possessed modern equipment which enabled it to carry out all the mapping and cartographic work needed for the social and economic development of the country, but the United Nations could play a valuable part in helping to maintain that equipment. There was, for instance, a lack of technicians qualified in photogrammetric instruments. It was to be hoped that the United Nations would send to the Congo a technician capable of maintaining and overhauling its precision equipment. There was also need for a surveyor, preferably French-speaking. Finally, the United Nations might grant scholarships for trainees. The Government of the Congo intended, moreover, to submit those three requests to the United Nations.

Mr. SAWYERR (Liberia) suggested that the Conference should consider the possibility of applying for scholarships to carry out programme of exchange of technicians among all the developing countries, for computation work as well as for exchange of data between countries. The current tendency to provide European or Asian experts was giving the whole matter a foreign flavour. He reminded the Conference that at the recent Geneva meeting he had referred to the need for incentives to stimulate the confidence of young technicians in their own ability to learn and do the work.

His country was extremely grateful to the Federal Republic of Germany for its assistance in the form of expert teams and aerial surveys. Such projects could be promoted, if not sponsored, by the United Nations.

Mr. SKUSE (Sierra Leone) said his country had received valuable aid from the Directorate of Overseas Surveys of the United Kingdom in topographical and cadastral mapping and in offers to provide training courses in specific skills. There was a great shortage of qualified staff to meet the coming need for field surveyors and other personnel. Technical assistance was also required for lithographic printing and the training of lithographers.

He suggested that the Conference should appeal for co-ordination among the agencies providing technical assistance. He also suggested, since Governments were unaware of all the facilities available and how to obtain them, that it would be helpful if the United Nations could ascertain and co-ordinate the requirements of member States.

The EXECUTIVE SECRETARY replying to a question by the representative of Sudan, explained that experts sent under OPEX Programme were regarded as employees of the Government concerned. Where the Government was unable to pay an adequate salary for an outside expert, the difference between local and international rates was made up by the United Nations Operational and Executive (OPEX) programme. The procedure for requesting an expert was the same as that followed by the BTAO.

Mr. KHALIFA (Sudan) said that the scholarship programme had not been very effective. He urged that the United Nations should provide more scholarships in the various branches of cartography so as to train qualified Africans to take over the highly technical posts now being filled by outside technicians. As an interim measure he asked the United Nations to increase the number of experts as well as their periods of service so that these experts can, without interruption, carry on the various survey projects in one country, including the training of surveyors of that country.

Mr. WASSEF (United Arab Republic) outlined the conclusions he had drawn from the discussions at the Conference and the papers submitted (particularly the report on cartographic activities in Africa). Excellent work in the various branches of cartography was done in Africa, and valuable experience was thereby being gained. The best way to arrange future work in Africa would be to pool experience and develop it on a sound scientific basis.

He suggested that consideration should be given to the possibility of setting up a joint African centre for technical work, where knowledge and experience could be

[1] Provisionally issued as E/CN.14/CART/SR.6.

shared and where technical work needing special equipment—for example, electronic computers—could be done, local problems solved in the light of experience, and advice given on where advanced technical training was available overseas. Such a centre would be of great benefit to Africa and would also be a token of mutual assistance. Assistance would be welcomed from the United Nations in obtaining highly-qualified personnel and equipment in the early stages, but Governments themselves would have the main responsibility for the project. It was important to make use of the experience acquired and to keep abreast of advances in science and cartography.

Mr. AHSTRAND (Observer, Sweden), speaking at the invitation of the PRESIDENT, pointed out that technical assistance was provided by a number of countries, including his own, outside the United Nations programme; but only a small proportion was used for cartographic projects.

He suggested that African States should try to secure a larger share of United Nations technical assistance funds for cartographic work, and that those countries which were prevented by climatic conditions from using their equipment the whole year round should lend it to other countries when it was not in use. It would also be useful if national surveying departments could compile lists of projects, indicating where outside assistance was needed, and if the Economic Commission for Africa could collect the lists and send a schedule of requirements to the survey departments of states members of the United Nations.

Mr. WASSEF (United Arab Republic), in reply to a request for further clarification from the representative of Nigeria, explained that he had mentioned electronic computing as an example of the kind of work that a joint centre should be able to do. Electronic computing was one of the essential tools for modern geodetic and photogrammetric work, but few countries could afford the equipment.

The Swedish representative's suggestion would fit in well with his own proposal: each African country would have to assess the amount and type of assistance that was necessary, and the joint centre would be the ideal channel for co-operation between those countries needing aid and those willing to give it.

He envisaged the centre as a joint effort by the countries of Africa to make the best use of available experience and knowledge, and to do the kind of work that was not economically possible at the national level.

The PRESIDENT said that a joint centre would be very useful in concentrating applications for technical assistance.

Mr. SAWYERR (Liberia) pointed out that the University of Milan was providing electronic computing services.

Mr. COKER (Nigeria) said that the United Kingdom Government also provided technical assistance.

Mr. INGHILLERI (Observer, Italy) speaking at the invitation of the PRESIDENT, described the activities of the Milan training centre in photogrammetry. These included promoting study and research in all photogrammetric fields; as acting technical and scientific consultant on all photogrammetric questions; organizing seminars and conferences; and, organizing courses for qualified photogrammetric engineers and experts. The Centre was intended to promote contacts and to bring about fruitful collaboration. It had already offered to help the Rhodesia survey to perform analytical triangulation computations.

Mr. WASSEF (United Arab Republic) said he could name at least ten excellent institutions which were ready to help. The Milan Institute was a fine one. What he had in mind, however, was helping Africa to help itself. Outside assistance was necessary and welcome, but development for the future should be within Africa and by Africans, leading to the time when no further outside aid was needed, apart from the normal interchange of information and publications. His proposal was that the African countries should pool their resources and obtain whatever help was necessary from the United Nations and individual countries, but with the idea of developing cartography in Africa to a level comparable with the latest developments in any country. Africa did not lack brains; goodwill, experience and technical assistance were available; all that was needed was a method of combining them to form the basis for the future development of Africa.

Mr. KHALIFA (Sudan) agreed with the representative of the United Arab Republic. He suggested, however, that the correct sequence would be first to set up the centre for higher training which he himself had proposed and then the joint centre.

Mr. WASSEF (United Arab Republic) replied that although the training centre was important, it would be unrealistic to leave the joint centre until the training centre had been established. There were many problems to be tackled, and nothing would be gained by waiting. The United Nations would presumably be ready to appoint experts to work at the centre.

Mr. COKER (Nigeria) stressed the importance of avoiding duplication of effort. The Commission for Technical Co-operation in Africa already existed and could combine with the proposed joint centre in co-ordinating the work of technical assistance.

Mr. WASSEF (United Arab Republic) emphasised that the joint centre was not to be a technical assistance concern: it was to be a joint effort by African countries to solve their own problems.

Mr. SIMPSON (Ghana) was in favour of developing existing facilities as centres for the use of all.

Mr. WASSEF (United Arab Republic) said that provided a common centre was established, it did not matter whether it was a new one or an extension of an existing one. What was needed was a joint centre to solve the technical problems of production in Africa.

Mr. MAMMO (Ethiopia) pointed out that the Conference was really discussing international co-operation, which was item 10 of the agenda.

The PRESIDENT said he understood the United Arab Republic's proposal to be that the United Nations should take the initiative in giving assistance in funds or experts to start the joint centre.

Mr. WASSEF (United Arab Republic) concurred. He suggested that the Conference should recommend that the United Nations be asked to examine the advantages of such a centre and advise on the feasibility of its establishment.

Mr. OKEC (Uganda) agreed with the representative of the United Arab Republic that a joint centre would solve Africa's cartographic problems, but thought the proposal a little too ambitious. It might be better to set up cartographic institutes on a regional basis which would co-operate with each other and exchange information and publications. The United Nations could help by providing staff to translate publications in the two working languages of the Conference.

Mr. GUEST (Kenya) drew attention to the problem of printing and distributing the results of field work, which was one of the most serious difficulties encountered in Kenya. Other countries might be faced with the same problem. An international or African centre could do valuable work in printing reports and producing coloured maps. The work already done should be used to the best advantage, and technical assistance in such matters was urgently required.

Mr. DIAGNE (Senegal) said he had noticed that the members of the Conference were unanimous in recognizing that all the African countries were in need of technical assistance. The main difficulty was how such assistance was to be distributed. He himself was in favour of the centre, but not along the lines proposed by the representative of the United Arab Republic, because that would not really be a technical assistance centre but a kind of clearing-house. In his view, the centre should be in a position to centralize all forms of technical assistance, and should work out a priority programme of help to the African countries.

Mr. YOWALOLA (Congo (Leopoldville)) thought that the problem could be solved by setting up the centre in a "neutral" region meeting all other requirements—technical, material and linguistic—*because both English and French were used in Africa.* The zone should therefore be both "neutral" and bilingual.

The PRESIDENT asked if any other representative wished to speak on the matter, otherwise the Conference would consider the next item on the agenda.

Organization of international co-operation

[Item 10 of the agenda]

Mr. BEN CHACHAME (Tunisia) agreed with the PRESIDENT that the last two items on the agenda were complementary and that it would be better to discuss and adopt resolutions on principles and leave matters of detail to be studied later, at any rate so far as international co-operation was concerned. Developments in cartographic science added to the types of maps enabling the needs of economic development to be met. The problems of economic development were not, however, the same manner in all African countries and maps, being a universal language, could contribute to uniting the countries.

The United States of America had prepared a very good document on the advantages of national cartographic services exchanging the results of their work (E/CN.14/CART/62). He regarded such exchanges as absolutely vital, because cartographic services must be homogenous and dovetail with one another over and beyond frontiers.

The American mission in Lybia had recently asked the Tunisian services to compare precision levelling in Lybia and Tunisia. That was an example of technical co-operation that all countries should follow. He would therefore propose that the Conference adopt a resolution inviting all African countries to exchange papers on the results of experiments such as the introduction of a land tenure system, cadastral surveys, and so on.

The PRESIDENT remarked that the system of exchange of information had already been operating for two years in the three east African countries.

Mr. SAWYERR (Liberia) said that technical assistance and international co-operation were two different things: one was technical aid and the other mutual assistance. Some of his comments during the discussion on technical assistance, for example, the need for scholarships, exchanges of personnel and facilities for the interchange of experience between countries, applied also to international co-operation.

Vice-Admiral DOS SANTOS FRANCO (Observer, IHB) speaking at the invitation of the PRESIDENT, outlined the work of the International Hydrographic Bureau. He said that the Bureau sought to achieve international technical co-operation through conferences, circular letters and publications. Conferences were held every five years and lasted for about two weeks. They constituted an effective means of international co-operation because of the decisions taken and the personal contacts made. In addition, the Bureau undertook enquiries by means of circular letters, and often collected information of general interest which was published in leaflet form. Lastly, the Bureau issued specialized periodicals such as the International Hydrographical Review, the International Hydrographical Bulletin and the Hydrographical Yearbook. The Bureau was a purely consultative body. Although its resolutions were in no way compulsory, they were usually carried out and consequently helped to ensure uniformity of working methods in the hydrographic field.

Mr. POMMERAUD (Chad) drew the attention of the Conference to the question of collaboration between neighbouring States in preparing maps covering frontier areas, in particular between French and English speaking countries. Aerial photographs of border areas often led to serious problems, because the photographers had to fly over the border to get a stereoscopic view. Moreover, from the purely photographic standpoint, no sector of the border area could be omitted, not even by approximating the published sheet lines to fit the general contour of the country. International co-operation on that point was therefore essential and he would propose that a resolution to that effect be adopted at the end of the current session.

Mr. HUMPHRIES (United Kingdom) said that in his long experience of mapping in Africa he had never met with any difficulty in overborder mapping. On the contrary, he had always found the greatest co-operation, for example in the case of west Uganda and the Congo and, more recently, the Sudan and north Uganda. Nevertheless, he would support a resolution on the lines suggested.

Mr. SAWYERR (Liberia) was in favour of a resolution calling for co-operation. Mount Kilimanjaro was an example of the value of co-operation, for observations to find out if the volcano was likely to erupt again could not be made by one country alone.

Mr. EVANS (Observer, CCTA) speaking at the invitation of the PRESIDENT, said his organization has always attached great importance to cartography in Africa. The Scientific Council for Africa had been established in 1950 and there was a very active Committee on Maps and Surveys, composed of the heads of governmental cartographic services. His organization would therefore be able to follow up any recommendations from the Conference, particularly as regards co-operation in uniform methods and middle grade training and member Governments could be told of the importance of placing their cartographic services at the disposal of others. The Chairman of the Maps and Surveys Committee had submitted a paper on its activities to the present Conference.

The CCTA had already published a climatological atlas for Africa. All CCTA member Governments had pledged full co-operation in mapping on boundary areas. The Committee on Maps and Surveys was ready to place its long experience in co-operation in cartography at the disposal of the Economic Commission for Africa; indeed, co-operation had started at the recent meeting in Nairobi between Mr. Tchang, the current and past Chairman of the Committee, and himself.

Mr. MAMMO (Ethiopia) said that a number of suggestions for centres had been made during the discussion. In his opinion, however, there should be only one centre, organized in co-operation with the United Nations.

Miss DELANY (Observer, Association of African Geological Surveys) described the activities of the Association, which had been set up in 1929.

There had never been any problem over boundaries, but two serious difficulties had been encountered. First, it was vital for international co-operation to be truly international, for passing political differences were of no importance in geology. Secondly, once the work had been done through international co-operation, it should be published by an international organization, such as the United Nations or one of its agencies. It would be deplorable if a map prepared by forty or fifty countries were to be published by a single country.

The meeting rose at 4.05 p.m.

SUMMARY RECORD OF THE SEVENTH PLENARY MEETING[1]

Held in the City Hall, Nairobi, on Friday 5 July 1963, at 2.35 p.m.

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President: **Mr. WARREN (Kenya)**

Organization of international co-operation *(continued)*

[Item 10 of the agenda]

The PRESIDENT reminded the Conference that the question of co-operation between countries in mapping bordering areas had been raised at the previous meeting and that there had been support for a suggestion that a resolution should be adopted concerning the need for co-operation, despite the fact that some countries had not experienced any difficulty.

The representative of Tunisia had suggested the regional exchange of technical information, and the Conference might wish to recommend that responsibility for facilitating such exchanges should be assumed by the Economic Commission for Africa.

The representative of the United Arab Republic had suggested the establishment of an institute with the following functions: to gather information; to assess the ability of the United Nations and other organizations to give technical assistance and determine the value of individual programmes; and to provide a central organization for the use of member States.

The observers for the International Hydrographic Bureau (IHB), the Commission for Technical Co-operation in Africa (CCTA) and the Association of African Geological Surveys (AAGS) had drawn attention to the volume of existing and past international co-operation.

Mr. COKER (Nigeria) suggested that the Conference should consider resolution 600 (XXI) of the Economic and Social Council quoted in document E/CN.14/CART/30 on the establishment of regional cartographic committees.

Mr. TRAIZET (Madagascar) pointed out that since its foundation CCTA had met periodically to discuss questions relating to co-operation. The CCTA Map Committee might perhaps extend its work to cover the whole of Africa.

Mr. COKER (Nigeria) said that the idea of establishing a regional committee was a good one, but there were already too many committees in existence. The work of CCTA and of the Economic Commission for Africa should not overlap and those two organizations should set up a single committee.

The PRESIDENT referred to the recent meeting in Nairobi between the Executive Secretary of the Conference and representatives of CCTA, and invited the Executive Secretary to outline the functions of the two organizations.

The EXECUTIVE SECRETARY explained that both the Economic Commission for Africa and CCTA had policy-making bodies composed of government representatives. At the working meeting in Nairobi it had been agreed that the two organizations should co-operate in carrying out their programmes. He was unable to comment on whether one of them could cover the other's work because the question of co-operation was being dealt with by higher authorities. He assured the Conference, however, that the Economic Commission for Africa intended to co-operate with all inter-governmental organizations in Africa in working for the benefit of the continent and had no intention of duplicating the work of others.

Mr. COKER (Nigeria) thanked the Executive Secretary for his explanation, but maintained that the Conference should consider his suggestion.

The PRESIDENT noted that the Economic Commision for Africa was conducting negotiations with CCTA and pointed out that the Conference had been asked to consider setting up a regional body under United Nations auspices.

Mr. KHALIFA (Sudan) supported the Nigerian representative's suggestion, particularly as some countries were not members of CCTA.

Mr. LOXTON (Kenya) said the Conference should decide which geographical areas the cartographical committees were to cover: the Economic Commission for Africa covered the whole of Africa, but the CCTA only Africa south of the Sahara. The Conference might consider the advisability of splitting Africa into smaller regions for the purpose under discussion.

Mr. SIMPSON (Ghana) suggested an ECA/CCTA coordinating committee for cartographic work, as he did not think all members of CCTA were also members of the United Nations.

Mr. EVANS (Observer, CCTA), in reply to a question from the PRESIDENT, said that, so far as he was aware, all members of CCTA were members of the United Nations although some north African countries were not members of CCTA. Membership of CCTA was open to all independent African countries, and the words "South

[1] Provisionally issued as E/CN.14/CART/SR.7.

of the Sahara" had been omitted from the title of the Commission at the Abidjan meeting in 1962.

Mr. WHITTAKER (Uganda) enquired if the observer for CCTA could outline the organization's cartographic policy, so that the Conference could judge whether it overlapped with the matter under consideration.

Mr. EVANS (Observer, CCTA) pointed out that the chairman of the Maps and Surveys Committee of CCTA would be better able to reply.

Mr. TRAIZET (Madagascar) (Chairman of the CCTA Maps and Surveys Committee) said, in reply to the question raised by the representative of Uganda, that that committee had met for the first time in 1953 at Bukavu to standardize map types so that they would be easier to understand. The Bukavu meeting had also recommended that there should be a uniform projection. The Committee had recommended the use of the modified Clarke ellipsoid of 1880, the adoption of the UTM projection in covering a lune width of 6 degrees for medium scale-terrestrial maps, the adoption of the sheet-line system of the *International Map of the World on the Millionth Scale* for larger scale maps, the substitution of metric scales for scales expressed in inches to the mile or in miles to the inch and the standardization of conventional signs. Finally, the Bukavu meeting had advocated the establisment of an Inter-African Committee for the Compilation of Maps and Topographical Surveys. That Committee had met in London in 1955, in Capetown in 1957, in Lisbon in 1960 and in Salisbury in 1962. In the course of those meetings the Committee had recommended the preparation of base maps on a very small scale which could be used in topical mapping. All those recommendations had been adopted and put into effect.

In so far as direct co-operation between member States was concerned, the necessity of exchanging topographical information, particularly for the compilation of frontier maps, had been emphasized.

In conclusion, he pointed out that CCTA was a purely African organization since the European States which had founded it were no longer anything but founder members participating in the discussions but having no voting rights. CCTA decisions were therefore taken by the African States. In his opinion, close collaboration between CCTA and the Economic Commission for Africa should be established.

Mr. EVANS (Observer, CCTA), in reply to a question from the representative of the United Arab Republic, read out the names of the member countries of his organization. There were twenty-four members. Belgium, France and the United Kingdom, which were founder members, were still closely associated with CCTA and attended meetings of the Assembly with full discussion rights but no right of vote; they contributed a very large proportion of the budget.

He said further, in reply to a question from the representative of Ethiopia, that the headquarters of the administration were in Lagos where the Secretary-General and the Deputy Secretary-General worked; there was a publications office in London, an Inter-African Soil Bureau in Paris, an Inter-African Labour Office in Brazzaville and a scientific secretariat in Nairobi.

In reply to a question from the PRESIDENT, he said that there was no physical maps and surveys centre, the subject being handled by a committee, which appointed a new chairman after each meeting.

The PRESIDENT said that CCTA already included most of the countries represented at the Conference, but many countries were still not members of the organization. He suggested that the Conference should consider whether it wished to propose a single survey centre for all the African countries or continue with CCTA's activities for its members and form a separate centre for the other countries.

Mr. COKER (Nigeria) suggested that the Economic Commission for Africa and CCTA should be asked to consider the possibility of working through a joint body instead of separately.

Mr. DIAGNE (Senegal) said he did not think the two systems were opposed since the Economic Commission for Africa grouped all the African States and the full members of CCTA were all African. He suggested that the Conference should request those States, which were not members of CCTA to join it or to say why they did not wish to do so. In the light of that information the Conference could, if necessary, discuss the question of establishing a single centre for the whole of Africa.

Mr. WASSEF (United Arab Republic) said that CCTA's function appeared to be solely to supply member States with practical technical information on how to prepare maps. As that function had now been achieved by the recommendation of uniform standards for Governments he asked what CCTA's future task would be.

Mr. SIMPSON (Ghana) thought that since the Committee on Maps and Surveys was an advisory body of CCTA, which had its own objectives, there was no reason to suggest that it should be replaced by another body.

Mr. EVANS (Observer, CCTA) added that the recent meeting of the heads of African States in Addis Ababa had agreed that CCTA should continue its functions and had instructed CCTA and the scientific directorate of the African and Malagasy Union to co-operate closely with the Economic Commission for Africa until the organization for united African States became operative, when CCTA would probably become the special organization for dealing with technical and scientific matters. It would seem, therefore, that the Addis Ababa meeting had regarded CCTA as the embryo of a pan-African technical and scientific development organization.

Mr. WASSEF (United Arab Republic) asked for the text of the resolution adopted by the meeting of the heads of African States.

Mr. EVANS (Observer, CCTA) promised to obtain the text for the following meeting, but assured the representative of the United Arab Republic that he had given the essence of the resolution.

The PRESIDENT invited comments from representatives of States not members of CCTA.

Mr. MAMMO (Ethiopia) said his country was not a member of CCTA. The subject being discussed, however, was the establishment, under United Nations auspices, of one central committee to handle cartography for all the States represented at the present Conference. In his

opinion, it would be best to set up such a committee within the Economic Commission for Africa; CCTA should not be disbanded, but its experience should be used to build up one central body for all the African States instead of having several committees in different places.

The PRESIDENT enquired if CCTA had a permanent cartographer or surveyor on its staff.

Mr. EVANS (Observer, CCTA) replied that there was no permanent cartographic staff. The Committee on Maps and Surveys served member Governments and was an *ad hoc* body.

Mr. KALIFA (Sudan) said his country was not member of CCTA. He was in favour of a single committee under the auspices of the Economic Commission for Africa.

The PRESIDENT invited comments from representatives of member States of CCTA.

Mr. COKER (Nigeria) said that in his country's experience the functions of CCTA and of the Economic Commission for Africa were more or less the same and help was needed from both according to the type of a project. He gave examples of assistance being received from each organization. He had no wish to see CCTA taken over by the Economic Commission for Africa: all he was suggesting was that they should agree to work together.

Mr. DIAGNE (Senegal) said that he would find it embarrassing to say whether or not his Government was satified with all the work of the Economic Commision for Africa. Some delegates had spoken of the establishment of a purely African body but they had not specified the work of that body. Some viewed the question from the point of view of co-operation, others from the point of view of technical assistance, and yet others from the purely scientific point of view. The Economic Commission for Africa, which grouped twenty-five African member States, already covered those three subjects.

Mr. BOMORY (Mali) wanted to know if all States had consulted their technicians on the advisability of joining CCTA. In his opinion the technicians were the only competent authorities in the matter. Furthermore, if the African States were already members of the Economic Commission for Africa and of CCTA, he did not see the use of establishing a third African body.

Regional projects

[Item 11 of the agenda]

The EXECUTIVE SECRETARY introduced document E/CN.14/CART/38 and explained that the projects referred to in it had been approved by the Economic Commission for Africa at its fifth session. The secretariat had the task of carrying out the work, and the Conference would help by making useful suggestions.

The PRESIDENT said there were two points to be considered: training, which had been thoroughly dealt with; and the setting up of a centre, which the representative of the United Arab Republic had suggested could be better discussed after the technical committees had met.

He asked for comments on the desirability of a regional centre for interpreting aerial surveys.

Mr. WASSAF (United Arab Republic) thought the matter should be considered as part of his proposal for the establishment of a joint centre to provide specialized technical services and act as a computing and information centre.

Mr. COKER (Nigeria) enquired if separate centres were envisaged for interpretation of aerial surveys and for training in photogrammetry and airborne geophysical prospecting.

The EXECUTIVE SECRETARY replied in the affirmative.

Mr. WASSEF (United Arab Republic) said he had merely asked what the role of CCTA would be once standardization was achieved. According to the representative of Nigeria, CCTA was interested in organizing scholarships and training, but the CCTA observer had made no mention of it.

Regarding the comments of the representative of Senegal on co-operation in Africa, as he saw it, CCTA and the other inter-governmental organizations concerned were useful for matters of general policy, but there was still a need for an organization to combine the efforts of the African countries to solve their technical production problems. Such an organization should be a body to which Governments could bring their problems and in which they could help to solve the problems of other countries. Its essential requirements were: a good library; technicians and experts; access to a good computing centre or a computing service of its own; close relations with the more important scientific centres of the world.

Mr. COKER (Nigeria) enquired why there should be two centres instead of one.

The EXECUTIVE SECRETARY pointed out that the secretariat was to carry out the instructions given to it in the work programme adopted by the Economic Commission for Africa.

The PRESIDENT suggested that further discussion should be postponed until the following meeting.

It was so agreed.

The meeting rose at 3.55 p.m.

SUMMARY RECORD OF THE EIGHTH PLENARY MEETING[1]

Held in the City Hall, Nairobi, on Monday, 8 July 1963, at 2.30 p.m.

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President: **Mr. WARREN (Kenya)**

International maps

[Item 12 of the agenda]

The PRESIDENT drew attention to the two documents to be considered: an information paper on the *International Map of the World on the Millionth Scale* (E/CN.14/CART/50), submitted by the secretariat, and another entitled Notes concerning aeronautical charts (E/CN.14/CART/52 and Add.1), submitted by the International Civil Aviation Organization (ICAO). He suggested that the two documents should be examined separately.

"International Map of the World on the Millionth Scale"

The PRESIDENT suggested that it would be interesting to learn from representatives whether their countries were able in practice to keep to the agreed sheet-line requirements for their sections of the International Map.

Mr. WHITTAKER (Uganda) said that the only published sheet he had seen, which had been produced as a result of the United Nations Technical Conference on the *International Map of the World on the Millionth Scale* held in Bonn in August 1962, was the Lindi sheet displayed in the current Cartographic Exhibition in Nairobi. The rather anaemic choice of colours seemed to be a retrogressive step and he asked the reason for the pink and mauve layers of the higher altitudes and other innovations.

Mr. URETA (Chief, Cartographic Section, Department of Economic and Social Affairs) said that the Bonn Conference had set up a working group composed of representatives of Chile, France, the Federal Republic of Germany, the United Kingdom and the United States of America, whose tentative findings and colour examples had been sent to him in New York. The working group was to meet again in the coming September to work out final conclusions, and it was hoped that the results would be ready in time for submission to the next session of the Economic and Social Council.

Mr. WHITTAKER (Uganda) enquired why the previous system of layer colours, which was mainly shades of brown, had been abandoned. The new system of red, pink, violet or mauve tones was a wide departure from the previously accepted system.

The EXECUTIVE SECRETARY said he believed that the mauve colour on aeronautical charts was to facilitate their use in artificial light.

Mr. WHITTAKER (Uganda) expressed doubts about the suitability of the new colours for African countries whose high plateau areas would be reproduced in red and pink.

Mr. GILLES (Ivory Coast) thought that the possible reason why brown had been abandoned was that its reproduction required a combination of colours whereas pink and mauve were easier to obtain.

Dr. KNORR (Federal Republic of Germany) said that the only reason for the change was to make the colours lighter for the mountains.

Mr. YOWALOLA (Congo (Leopoldville)) suggested that the United Nations might organize another conference restricted to African countries to study the possibility of issuing a world map on the millionth scale in keeping with the geographical standards of the African continent. Most of the African countries had not been represented at the Bonn Conference, and the specifications failed to fulfil the complex task of preparing the map.

The PRESIDENT pointed out that Mr. Ureta has stated that the African countries had been represented at the Bonn Conference. Kenya, on the other hand, had had difficulties with the *International Map of the World* because of limited resources. It would take six sheets to cover Kenya, but the map had been made in two sheets because Kenya could not afford to draw, print and maintain six sheets. Other countries had greater resources and perhaps no other country was in the same situation as Kenya, yet it was possible that they would pay lip-service to the agreement on the *International Map of the World* but be obliged to depart from it when covering their own territory.

World aeronautical charts

Mr. DELIENNE (France) drew attention to the proposal of the French National Geographic Institute in connexion with international co-operation on maps that straddled several countries (E/CN.14/CART/17). The

[1] Provisionally issued as E/CN.14/CART/SR.8.

Institut géographique national had based its formula of co-production on considerations of economy, flexibility and maximum usefulness. Each country was invited to produce its own rough sketches, outlines and notes of its own territory and to pass them on to the adjoining country, together with the base documents used. Each State would draft and edit the sheets according to its own standards. Trial proofs would be exchanged, each country checking on its own territory. Later on, when the maps were being reprinted, revised copies would be exchanged, and again each country would check on its own territory. He added that if the country producing the greater part of a map straddling two States had sole responsibility for drafting that section of the map which overlapped the adjacent territory, then that section might not be so accurate nor so carefully prepared. Co-operation between both countries was therefore vital. Each could indicate the names of towns or places in its own language, adding them in brackets in the language of the country communicating the draft.

Mr. TIMMER (Observer, International Civil Aviation Organization), speaking on the invitation of the PRESIDENT, referred to document E/CN.14/CART/52 and Add.1, and appealed to representatives to urge their national authorities to comply with their Governments' obligations under the International Convention on Civil Aviation. Those obligations, which were outlined in the document, included the provision of certain charts in accordance with the specifications in annex 4 to the Convention and the publication of accurate and timely aeronautical information in accordance with the provisions of annex 15 to the Convention.

Report on credentials

[Item 3 of the agenda]

The PRESIDENT read the report of the Credentials Committee, which indicated that the credentials of representatives of the following countries had been examined and found in good and due form, the number of representatives being indicated in parentheses: Chad (1), Congo (Leopoldville) (2), Dahomey (1), Ethiopia (4), Federation of Rhodesia and Nyasaland (1), France (4), Gabon (1), Ghana (2 and 1 observer), Ivory Coast (1), Kenya (14), Liberia (1), Madagascar (2), Mali (1), Morocco (1), Niger (1), Nigeria (1), Senegal (1), Sierra Leone (2), Sudan (3), Tanganyika (2), Tunisia (2), Uganda (2), United Arab Republic (3), United Kingdom (2), Upper Volta (1).

Credentials had also been received for observers from the following countries: Belgium, Canada, Federal Republic of Germany, Israel, Italy, Netherlands, Sweden, Switzerland, United States of America, Union of Soviet Socialist Republics; and from the following international organizations: International Civil Aviation Organization (ICAO), United Nations Educational, Scientific and Cultural Organization (UNESCO), World Meteorological Organization (WMO), Commission for Technical Co-operation in Africa (CCTA), International Hydrographic Bureau (IHB) and Association of African Geological Surveys (AAGS).

The report on credentials was unanimously adopted.

Report of the Conference

[Item 16 of the agenda]

The PRESIDENT informed the Conference that the final report would be drawn up in the same form as volume 1 of the report of the Third United Nations Regional Cartographic Conference for Asia and the Far East (E/CONF.36/2) which had been circulated to representatives. He outlined the contents of the report and suggested that, since the Conference had now completed its agenda, representatives should discuss the resolutions to be included in chapter II of the report.

Mr. OKEC (Uganda) proposed in connexion with the item "Organization of international co-operation" a draft resolution, co-sponsored by Kenya, Tanganyika and Uganda, which he read:

> "The delegations of Tanganyika, Uganda and Kenya wish it to be noted that a high degree of co-ordination has already been achieved in the cartographic activities of their three countries. In co-operation with the Directorate of Overseas Surveys, comprehensive primary and secondary control has been extended throughout the three countries, a common specification has been arrived at for basic 1:50,000, 1:250,000 mapping and mapping at other scales and a close co-ordination of activity in other fields such as training and standard qualifications for recruitment has been achieved by regular consultation between the heads of the national Survey Departments. The delegations of Tanganyika, Uganda and Kenya recommend that in view of the great benefits which they have derived from the close association of the activities of their territorial cartographic organizations, consideration should be given by the Conference to the encouragement of similar sub-regional affiliations elsewhere in Africa, and the three delegations further recommend that at the second United Nations regional cartographic conference for Africa renewed consideration should be given to the results which formation of sub-regions on this basis have achieved with a view to exchange of ideas and experience gained in sub-regions."

Mr. COKER (Nigeria) said he would not oppose the resolution, but there were differences of language and background which might make sub-regional co-operation difficult for other regions: the east African countries had the advantage of common origin. The resolution seemed to him too comprehensive, and over-ambitious at the present juncture.

Mr. DICKSON (Tanganyika) proposed a resolution under the same agenda item, concerning the distribution of bibliographical information.

Mr. BEN GHACHAME (Tunisia) said that his delegation had sent in to the secreteriat four draft resolutions to be submitted to the Conference.

The first was a motion of thanks to the Government of Kenya for the steps taken to ensure the smooth working of the Conference and for the hospitality given to those taking part in the work of the Conference.

The second concerned technical assistance, and requested the United Nations (*a*) to give priority to applications for assistance intended to establish, develop or

modernize national cartographic services; (*b*) to help in carrying through projects in connexion with cartography, including the setting up of a regional centre for professional training and for mapping; (*c*) to instruct the Regional Adviser on cartography to supervise the implementation of the resolutions and recommendations of the Conference; and (*d*) to grant technical assistance to countries in the region, so that they might be represented at all meetings concerning cartography.

The third draft resolution concerned international co-operation in cartographic matters. It recommended that countries of the region take steps to distribute cartographic publications and documents through the Economic Commission for Africa, to exchange information on the subject, and, if need be, to link up the various geodetic and precise levelling networks.

Finally, the fourth draft resolution recommended that the convening of the second cartographic conference for Africa be not later than 1966.

The PRESIDENT summarized the resolution proposed by the Tunisian representative.

Mr. HALIM (United Arab Republic) said he had intended proposing resolutions on lines similar to some of those already suggested. He proposed that representatives should combine their resolutions when possible.

The PRESIDENT remarked that that had been the secretariat's purpose in including the current item on the agenda.

Mr. SAWYERR (Liberia) agreed with the representative of the United Arab Republic.

He would like to see the following points included in the resolutions of the Conference: the possibility of obtaining financial assistance through the United Nations; the mention of United Nations finance in the Sudan representative's resolution on training; fellowships for the exchange of personnel with facilities for skilled work in different countries.

Mr. DIAGNE (Senegal) agreed with the remarks of the previous speakers. In addition, he suggested that the Conference might adopt a resolution recommending the countries represented at the Conference to take a deeper interest in mapping, and to set up national committees on mapping and national topographical services.

Mr. COKER (Nigeria) pointed out that there was a danger of overlooking some of the points raised during earlier discussions. It would be better to examine the summary records before deciding on resolutions.

The PRESIDENT assured the representative of Nigeria that final resolutions would not be discussed before the next plenary meeting, when texts would be presented. The current discussion was to enable representatives to prepare resolutions and to combine those which were similar.

Mr. HUMPHRIES (United Kingdom) enquired if resolutions would also be submitted by the technical committees.

Mr. HALIM (United Arab Republic) asked if he was right in assuming that the committees' resolutions would be on purely technical matters, in contrast to the more general resolutions submitted to the plenary meeting. He would not want any technical resolutions to be omitted because of a misapprehension.

The PRESIDENT replied in the affirmative to the representatives of the United Kingdom and the United Arab Republic.

The meeting rose at 3.50 p.m.

SUMMARY RECORD OF THE NINTH PLENARY MEETING[1]

Held in the City Hall, Nairobi, on Wednesday, 11 July 1963, at 2.35 p.m.

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President: **Mr. WARREN (Kenya)**

Report of the Conference *(continued)*

[Item 16 of the agenda]

CONSIDERATION OF DRAFT RESOLUTIONS

The PRESIDENT invited representatives to consider the draft resolutions which had been distributed as documents E/CN.14/CART/L.1 to L.21. He suggested starting with those submitted by representatives who would not be present the following day.

Mr. DICKSON (Tanganyika), supported by Mr. WHITTAKER (Uganda) moved the adoption of the draft resolution on preparation of a bibliography (E/CN.14/CART/L.11).

The draft resolution was adopted by 15 votes to 2 with 3 abstentions.[2]

The PRESIDENT suggested that draft resolutions in the two documents E/CN.14/CART/L.7 and E/CN.14/CART/L.19 should be considered next, as they were on related subjects.

Mr. BAMORY (Mali), supported by Mr. TRAIZET (Madagascar), moved the adoption of the draft resolution on exchange of cartographic documents (E/CN.14/CART/L.7)

The draft resolution was adopted by 21 votes to none with 3 abstentions.[3]

Mr. WHITTAKER (Uganda), supported by Mr. WILLIAMS (Kenya), moved the adoption of the draft resolution on exchange of typical sheets (E/CN.14/CART/L.19).

The draft resolution was adopted by 15 votes to none with 10 abstentions.[4]

Mr. COKER (Nigeria), supported by Mr. DIAGNE (Senegal), moved the adoption of the draft resolution on sub-regional meetings (E/CN.14/CART/L.19).

Mr. SAWYERR (Liberia) proposed an amended version of the operative paragraph to eliminate the suggestion that Africa should be divided.

The proposed amendment was defeated.

Mr. WASSEF (United Arab Republic), supported by Mr. SAWYERR (Liberia) proposed that the operative paragraph should be amended to read as follows:

"*Recommends* that the Economic Commission for Africa should assist in the organization of sub-regional cartographic conferences."

Mr. SIMPSON (Ghana) proposed that the word "divided" should be replaced by the word "grouped".

After a brief discussion, Mr. COKER (Nigeria) and Mr. SIMPSON (Ghana) accepted the amendment proposed by the representative of the United Arab Republic.

The PRESIDENT put the draft resolution as amended to the vote.

The draft resolution as amended, was adopted by 14 votes to none with 8 abstentions.[5]

The PRESIDENT invited the Conference to consider remaining draft resolutions in chronological order.

Mr. BEN GHACHAME (Tunisia) supported by Mr. KHALIFA (Sudan), Mr. HAKAM (Morocco), Mr. EL BAY YOU (United Arab Republic) and Mr. DIAGNE (Senegal), moved the adoption of the draft resolution in connexion with geodetic work (E/CN.14/CART/L.1)

The draft resolution was adopted by 20 votes to none with 1 abstention.[6]

Mr. KHALIFA (Sudan), supported by Mr. SAWYERR (Liberia) and Mr. WHITTAKER (Uganda), moved the adoption of the draft resolution on a second United Nations regional cartographic conference for Africa (E/CN.14/CART/L.2 Rev.1).

Mr. WASSEF (United Arab Republic) proposed the deletion of the words: "which are still in the early stages of cartography" in the second line of the paragraph beginning: "*Noting*".

Mr. WILLIAMS (Kenya) seconded the amendment.

The amendment was adopted by 21 votes to none with 1 abstention.

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[1] Provisionally issued as E/CN.14/CART/SR.9.

[2] For the text of the resolution, as adopted, see *United Nations Regional Cartographic Conference for Africa*, vol. 1, *Report of the Conference* (Sales No.: 64.I.2), p. 10, resolution 15.

[3] For the text of the resolution, as adopted, see *United Nations Regional Cartographic Conference for Africa*, vol. 1, *Report of the Conference* (Sales No.: 64.I.2), p. 10, resolution 13.

[4] For the text of the resolution, as adopted, see *United Nations Regional Cartographic Conference for Africa*, vol. 1, *Report of the Conference* (Sales No.: 64.I.2), p. 10, resolution 14.

[5] For the text of the resolution, as adopted, see *United Nations Regional Cartographic Conference for Africa*, vol. 1, *Report of the Conference* (Sales No.: 64.I.2), p. 7, resolution 2.

[6] For the text of the resolution, as adopted, see *United Nations Regional Cartographic Conference for Africa*, vol. 1, *Report of the Conference* (Sales No.: 64.I.2), p. 10, resolution 16.

Mr. KOTTLER (Uganda) proposed the following amendments: the insertion of an additional paragraph before the two operational clauses:

"*Noting* further that in the present Conference technical documents submitted by delegates and observers were not available until the Conference had assembled and that some papers were not even published in the second week of the Conference and that delegates had insufficient time to study them,"

and the insertion of a third operative paragraph.

"3. *Recommends* further that in any future conferences technical papers should be circulated to all delegates so as to reach them at least one month before the opening of the conference, and that during conferences papers concerned solely with the administration and business of the conference should be circulated."

Mr. DIAGNE (Senegal) seconded the amendment.

The amendment was adopted by 14 votes to 4 with 3 abstentions.

Mr. WASSEF (United Arab Republic) enquired who would be responsible for circulating the working papers.

The PRESIDENT replied that the Economic Commission for Africa had the responsibility. The secretariat had made every effort to circulate documents for the present Conference a month in advance, but had been hampered by their late arrival.

Mr. WASSEF (United Arab Republic) remarked that that situation was common to most conferences.

The PRESIDENT invited the Conference to vote on the draft resolution as amended by the United Arab Republic and Uganda.

The draft resolution as amended was adopted by 13 votes to none with 10 abstentions.[7]

Mr. KHALIFA (Sudan), supported by Mr. WASSEF (United Arab Republic), Mr. DIAGNE (Senegal), Mr. HAKAM (Morocco), Mr. AGNAMEY (Dahomey) and Mr. SAWYERR (Liberia), moved the adoption of the draft resolution on technical assistance requirements (E/CN.14/CART/L.3)

The draft resolution was adopted by 18 votes to none with 4 abstentions.[8]

Mr. WASSEF (United Arab Republic), supported by Mr. KHALIFA (Sudan), moved the adoption of the draft resolution on joint centres for specialized technical services (E/CN.14/CART/L.4).

The draft resolution was adopted by 12 votes to none with 9 abstentions.[9]

Mr. DIAGNE (Senegal), supported by Mr. EL BAY YOU (United Arab Republic), Mr. SAWYERR (Liberia) and Mr. AGNAMEY (Dahomey), moved the adoption of the draft resolution on training centres for technical personnel (E/CN.14/CART/L.5).

The draft resolution was adopted by 12 votes to none with 10 abstentions.[10]

Mr. KHALIFA (Sudan), supported by Mr. WASSEF (United Arab Republic), Mr. TRAIZET (Madagascar), Mr. SAWYERR (Liberia) and Mr. BEN GHACHAME (Tunisia), moved the adoption of the draft resolution on the cartographic committees of the Economic Commission for Africa (E/CN.14/CART/L.6).

The draft resolution was adopted by 14 votes to none with 8 abstentions.[11]

Mr. DIAGNE (Senegal), supported by Mr. WASSEF (United Arab Republic), Mr. SAWYERR (Liberia), Mr. AGNAMEY (Dahomey), Mr. HAKAM (Morocco), Mr. BEN GHACHAME (Tunisia), Mr. KHALIFA (Sudan) and Mr. BAMORY (Mali), moved the adoption of the draft resolution on national cartographic services (E/CN.14/CART/L.8).

The draft resolution was adopted by 18 votes to none with 4 abstentions.[12]

Mr. BEN GHACHAME (Tunisia), supported by Mr. WASSEF (United Arab Republic), Mr. SAWYERR (Liberia), Mr. KHALIFA (Sudan) and Mr. DIAGNE (Senegal), moved the adoption of the draft resolution expressing thanks to the Government of Kenya (E/CN.14/CART/L.9).

The draft resolution was adopted by acclamation.[13]

Mr. HAKAM (Morocco), supported by Mr. DIAGNE (Senegal) and Mr. AGNAMEY (Dahomey) moved the adoption of the draft resolution on implementation of requests for technical assistance (E/CN.14/CART/L.10).

The draft resolution was adopted by 20 votes to none with 3 abstentions.[14]

Mr. MAMMO (Ethiopia) supported by Mr. DIAGNE (Senegal), Mr. HAKAM (Morocco), Mr. DE MASSON D'AUTUME (Gabon), Mr. POMMERAUD (Chad) and Mr. BEN GHACHAME (Tunisia), moved the adoption of the draft resolution on centralisation of cartographic institutions (E/CN.14/CART/L.12).

Mr. WASSEF (United Arab Republic), supported by Mr. TRAIZET (Madagascar), proposed that in the second line of the preamble the word "would" should be replaced by the word "might".

The amendment was adopted by 11 votes to 4 with 5 abstentions.

The draft resolution as amended was adopted by 16 votes to 1 with 16 abstentions.[15]

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[7] For the text of the resolution, as adopted, see *United Nations Regional Cartographic Conference for Africa*, vol. 1, *Report of the Conference* (Sales No.: 64.I.2), p. 9, resolution 1.

[8] For the text of the resolution, as adopted, see *United Nations Regional Cartographic Conference for Africa*, vol. 1, *Report of the Conference* (Sales No.: 64.I.2), p. 8, resolution 6.

[9] For the text of the resolution, as adopted, see *United Nations Regional Cartographic Conference for Africa*, vol. 1, *Report of the Conference* (Sales No.: 64.I.2), p. 9, resolution 12.

[10] For the text of the resolution, as adopted, see *United Nations Regional Cartographic Conference for Africa*, vol. 1, *Report of the Conference* (Sales No.: 64.I.2), p. 9, resolution 10.

[11] For the text of the resolution, as adopted, see *United Nations Regional Cartographic Conference for Africa*, vol. 1, *Report of the Conference* (Sales No.: 64.I.2), p. 8, resolution 4.

[12] For the text of the resolution, as adopted, see *United Nations Regional Cartographic Conference for Africa*, vol. 1, *Report of the Conference* (Sales No.: 64.I.2), p. 8, resolution 7.

[13] For the text of the resolution, as adopted, see *United Nations Regional Cartographic Conference for Africa*, vol. 1, *Report of the Conference* (Sales No.: 64.I.2), p. 11, resolution 22.

[14] For the text of the resolution, as adopted, see *United Nations Regional Cartographic Conference for Africa*, vol. 1, *Report of the Conference* (Sales No.: 64.I.2), p. 5, resolution 5.

Mr. WILLIAMS (Kenya), supported by Mr. DIAGNE (Senegal), Mr. QUIGGIN (Federation of Rhodesia and Nyasaland), Mr. COKER (Nigeria), Mr. SKUSE (Sierra Leone), Mr. SIMPSON (Ghana) and Mr. BAMORY (Mali), moved the adoption of the draft resolution on survey of training facilities in Africa (E/CN.14/CART/L.13).

Mr. WASSEF (United Arab Republic), supported by Mr. KHALIFA (Sudan), proposed the addition of the following item to the operative paragraph:

"(*g*) Qualifications of teaching staff."

The amendment was adopted by 16 votes to 1 with 7 abstentions.

Mr. SIMPSON (Ghana), supported by Mr. SAWYERR (Liberia), proposed the following additional operative paragraph:

"*Further recommends* that the Commission should consider the establishment of some of the existing centres as centres of specialized studies to be suitably equipped and staffed to serve the needs of all countries."

Mr. WASSEF (United Arab Republic) proposed the insertion of the word "training" before "centres". The amendment was accepted by Mr. SIMPSON (Ghana) and Mr. SAWYERR (Liberia).

The PRESIDENT invited the Conference to vote on the amendment of Ghana as amended.

The voting was 2 in favour, 2 against and 17 abstentions.

The amendment was rejected.

The PRESIDENT invited the Conference to vote on the draft resolution as amended by the United Arab Republic.

The draft resolution as amended was adopted by 12 votes to none with 10 abstentions.[16]

The meeting rose at 4.05 p.m.

[15] For the text of the resolution, as adopted, see *United Nations Regional Cartographic Conference for Africa*, vol. 1, *Report of the Conference* (Sales No.: 64.I.2), p. 9, resolution 8.

[16] For the text of the resolution, as adopted, see *United Nations Regional Cartographic Conference for Africa*, vol. 1, *Report of the Conference* (Sales No.: 64.I.2), p. 9, resolution 11.

SUMMARY RECORD OF THE TENTH PLENARY MEETING[1]

Held in the City Hall, Nairobi, on Friday, 12 July 1963, at 10.05 a.m.

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President: **Mr. WARREN (Kenya)**

Report of the Conference *(concluded)*

[Item 16 of the agenda]

CONSIDERATION OF DRAFT RESOLUTIONS *(concluded)*

The PRESIDENT invited representatives to continue their considerations of the draft resolutions that had been circulated (E/CN.14/CART/L.15-22).

Mr. SIMPSON (Ghana), supported by Mr. WILLIAMS (Kenya), Mr. KHALIFA (Sudan), Mr. SAWYERR (Liberia), Mr. GOURMENT (Niger), Mr. TRAIZET (Madagascar) and Mr. DE MASSON D'AUTUME (Gabon) moved the adoption of the draft resolution on international co-operation (E/CN.14/CART/L.15/Rev.1).

Dr. WASSEF (United Arab Republic), thought it would be inappropriate for the Conference to discuss the resolutions at that time, because the whole question of technical co-operation in Africa, including the role of the Commission for Technical Co-operation in Africa (CCTA) was still under consideration by the Heads of African States.

Mr. SIMPSON (Ghana) explained that he had in mind a committee through which the Economic Commission for Africa and CCTA could co-ordinate their activities. He did not envisage a merger, for each organization had its own special functions.

Mr. AGNAMEY (Dahomey) said he failed to see the validity of the objection raised by the representative of the United Arab Republic. The draft resolution merely requested that the Cartographic Unit of the Economic Commission for Africa should continue to collaborate with CCTA until the Heads of African States had taken a definite decision on the subject.

Mr. TRAIZET (Madagascar) agreed with the remarks of the representative of Dahomey. The draft resolution in no way anticipated the decision which would later be taken by the Heads of African States concerning the future of CCTA. It merely aimed at ensuring that co-operation between CCTA and the Economic Commission for Africa was maintained.

The PRESIDENT invited the Conference to vote on the proposal of the representative of the United Arab Republic that the subject should not be discussed nor a resolution on it adopted.

The proposal of the United Arab Republic was rejected by 12 votes to 5 with 3 abstentions.

The draft resolution was adopted by 11 votes to 4 with 4 abstentions.[2]

Mr. WILLIAMS (Kenya), supported by Mr. QUIGGIN (Federation of Rhodesia and Nyasaland) and Mr. WHITTAKER (Uganda) moved the adoption of the draft resolution on geodesy, E/CN.14/CART/L.16/Rev.1.

Mr. SIMPSON (Ghana) proposed the deletion of sub-paragraphs 2 and 4 of the operative paragraph.

Mr. KHALIFA (Sudan) disagreed with sub-paragraph 3 of the operative paragraph because his country had already completed an east to west chain along parallel 13°30′.

Mr. TRAIZET (Madagascar) considered that sub-paragraphs 2 and 4 of the operative paragraph should be maintained.

Mr. DE MASSON D'AUTUME (Gabon) considered the word "datum" inappropriate. He suggested that sub-paragraph 2 should read: "Future work should be based on the already existing and adjusted arc of the 30th meridian".

Mr. SIMPSON (Ghana) explained that he had proposed the deletion of sub-paragraphs 2 and 4 because the arc of the 30th meridian and the Clarke 1880 figure were not used by all African States. In reply to a remark by the President, who pointed out that the matter had already been decided by CCTA of which Ghana was a member, he said it was for States to decide whether or not to follow the recommendations.

Dr. WASSEF (United Arab Republic) proposed that sub-paragraph 4 of the operative paragraph should be amended to read: "Countries in Africa should consider the adoption of a common figure of the earth for geodetic computation". It would be wiser not to recommend the

[1] Provisionally issued as E/CN.14/CART/SR.10.

[2] For the text of the resolution, as adopted, see *United Nations Regional Cartographic Conference for Africa*, vol. 1, *Report of the Conference* (Sales No.: 64.I.2), p. 7, resolution 3.

Clarke 1880 figure because recent developments in networks indicated that it was not the best one for Africa.

Mr. WILLIAMS (Kenya) said that paragraph 4 was taken from a recommendation by a meeting of specialists in cartography and topographical surveys held at Bukavu in September 1953 and quoted in document E/CN.14/CART/36 submitted by the Commission for Technical Co-operation in Africa.

Mr. AGNAMEY (Dahomey) thought it would be wiser to continue to use the modified Clarke 1880 ellipsoid until the exact form of the globe had been determined on the world plane.

Mr. TRAIZET (Madagascar) said he fully supported the opinion of the representative of Dahomey. Work so far carried out in Africa covered regions, the extent of which was far from negligible. Adoption of the amendment proposed by the representative of the UAR would lead to a setback rather than an advance. The main thing was to adopt a common ellipsoid, even if it had to be changed later. He personally approved the draft resolution submitted by the representative of Kenya; he hoped, however, that the Conference would adopt the purely drafting change to sub-paragraph 2 suggested by the representative of Gabon.

Dr. WASSEF (United Arab Republic) hoped that the Conference would not become involved in lengthy discussions on technical aspects. He was convinced that it would be unwise to recommend the Clarke 1880 ellipsoid for developing countries. If a common figure were recommended by the Conference, it might be possible to decide on a final figure within, say, two years.

The PRESIDENT invited the Conference to vote on the amendment of the United Arab Republic.

The amendment was rejected by 11 votes to 5 with 4 abstentions.

The PRESIDENT drew attention to the amendment of Sudan, that sub-paragraph 3 of the operative paragraph be deleted.

Mr. DE MASSON D'AUTUME (Gabon) thought it would be difficult to ask that the link from the arc into West Africa should be along a single parallel of latitude. He proposed that the words "along the 12th parallel of latitude" be deleted from sub-paragraph 3.

Mr. KHALIFA (Sudan) withdrew his amendment in favour of the amendment proposed by the representative of Gabon.

The PRESIDENT invited the Conference to vote on the amendment proposed by the representative of Gabon.

The amendment was adopted by 20 votes to none with 1 abstention.

The PRESIDENT invited the Conference to vote on the amendment of the representative of Ghana, that sub-paragraphs 2 and 4 of the operative paragraph be deleted.

The amendment was rejected by 7 votes to 1 with 10 abstentions.

The PRESIDENT invited the Conference to vote on draft resolution in E/CN.14/CART/L.16/Rev.1, as amended by the representative of Gabon.

The draft resolution as amended, was adopted by 20 votes to none with 1 abstention.[3]

Dr. WASSEF (United Arab Republic) supported by Mr. KHALIFA (Sudan), Mr. SKUSE (Sierra Leone), Mr. WHITTAKER (Uganda) and Mr. TARRADE (Upper Volta) moved the adoption of draft resolution in E/CN.14/CART/L.17 containing a vote of thanks to the Economic Commission for Africa.

The draft resolution was adopted by acclamation.[4]

Dr. WASSEF (United Arab Republic), supported by Mr. SAWYERR (Liberia) moved the adoption of the draft resolution in E/CN.14/CART/L.18 on hydrographic surveying with the following amendments:

(*a*) Amendment of the title to "HYDROGRAPHY";

(*b*) Deletion of the words "of" before the words "a joint" in the penultimate line;

(*c*) The title "International Hydrographic Bureau" in the penultimate and last lines to be written with initial capitals.

The amendments were adopted by 15 votes to none with 4 abstentions.

The draft resolution as amended, was adopted by 14 votes to none with 6 abstentions.[5]

Mr. WILLIAMS (Kenya) supported by Dr. WASSEF (United Arab Republic), Mr. SAWYERR (Liberia), Mr. KHALIFA (Sudan) and Mr. DIAGNE (Senegal) moved the adoption to the draft resolution in E/CN.14/CART/L.20/Rev.1., on geographical names.

The draft resolution was adopted by 19 votes to none with 2 abstentions.[6]

The PRESIDENT informed the Conference that the resolution contained in E/CN.14/CART/L.21/Rev.1 had been withdrawn.

Mr. SKUSE (Sierra Leone) supported by Mr. SAWYERR (Liberia), Dr. WASSEF (United Arab Republic) and Mr. HAKAM (Morocco) moved the adoption of the draft resolution in E/CN.14/CART/L.22, on international maps.

The draft resolution was adopted by 17 votes to none with 5 abstentions.[7]

Consideration of the reports of the Committees of the Conference

Report of Committee I (E/CN.14/CART/100)

Mr. TRAIZET (Madagascar) pointed out that the report did not mention the discussion which had taken

[3] For the text of the resolution, as adopted, see *United Nations Regional Cartographic Conference for Africa*, vol. 1, *Report of the Conference* (Sales No.: 64.I.2), p. 13, resolution 17.

[4] For the text of the resolution, as adopted, see *United Nations Regional Cartographic Conference for Africa*, vol. 1, *Report of the Conference* (Sales No.: 64.I.2), p. 11, resolution 22.

[5] For the text of the resolution, as adopted, see *United Nations Regional Cartographic Conference for Africa*, vol. 1, *Report of the Conference* (Sales No.: 64.I.2), p. 9, resolution 9.

[6] For the text of the resolution, as adopted, see *United Nations Regional Cartographic Conference for Africa.* vol. 1, *Report of the Conference* (Sales No.: 64.I.2), p. 11, resolution 20.

[7] For the text of the resolution, as adopted, see *United Nations Regional Cartographic Conference for Africa*, vol. 1, *Report of the Conference* (Sales No.: 64.I.2), p. 10, resolution 19.

place in Committee I on the necessity of continuing the connexions between the precise levelling executed by the various states. He therefore proposed that the following sentence should be added at the end of the third paragraph of section 1: "At the request of several delegations, the Committee also decided to recommend that the necessary connexions should be effected within a reasonable time between the various first-order precise levelling networks established by the States."

Mr. BEN GHACHAME (Tunisia) supported the proposal of the representative of Madagascar. That addition was, moreover, in accordance with the provisions of resolution 1 adopted by the Conference.

The amendment was adopted by 12 votes to none with 5 abstentions.

Mr. POMMERAUD (Chad) referred to the first paragraph of the section entitled "Electronic processing of geodetic data" and recalled that certain delegations had requested that the question of the purchase and the hire of an electronic computer should be considered. The French text, however, spoke only of the purchase. He suggested, therefore, that the words "and obtain an electronic computer jointly" be replaced by the words "so as to have an electronic computer at their disposal".

Mr. TRAIZET (Madagascar) proposed that the report Committee I be adopted with the suggested amendments.

Mr. SAWYERR (Liberia) remarked that the point raised by the representative of Chad had not been discussed by Committee I, so that if the amendment were adopted it would reflect a Conference rather than a Committee I decision.

The PRESIDENT said that the English text conformed with the decision of Committee I. In the absence of any objection, he invited a seconder for the adoption of the report.

Mr. HAKAM (Morocco), Mr. TARRADE (Upper Volta), Mr. KHALIFA (Sudan) and Mr. DIAGNE (Senegal) seconded the adoption of the report.

The report of Committee I was adopted by 18 votes to none with 1 abstention.[8]

Report of Committee II (E/CN.14/CART/101)

Dr. WASSEF (United Arab Republic), Chairman of Committee II, moved the adoption of the report, with the following amendments:

Deletion of the words "and infra-red photography" in the fifth line of paragraph 5 on page 3.

Amendment of the last three words of the sentence in the ninth line of section 6 on page 3 to "whenever conditions permit".

Mr. DIAGNE (Senegal), Mr. KHALIFA (Sudan), Mr. BEN GHACHAME (Tunisia) and Mr. BAMORY (Mali) seconded the adoption of the report, as amended.

The report of Committee II, as amended, was unanimously adopted.[9]

Report of Committee III (E/CN.14/CART/103)

The PRESIDENT invited the Conference to consider the draft report of Committee III and drew the attention of members to the draft resolution on the last page of the report.

Mr. THOMPSON (Observer, World Meteorological Organization) speaking at the invitation of the PRESIDENT, suggested the following amendment: in the last line on page 1, the words "or more" should be inserted before "projections", so that the last part of the sentence would read: "on one or more projections and scales".

Mr. DE MASSON D'AUTUME (Gabon) approved the amendment suggested by the observer for WMO but suggested that it be drafted as follows: "appealed to African cartographic services to plan and produce standard base maps on one or more common projections and common scales".

Dr. WASSEF (United Arab Republic) enquired the reason for the proposed amendment.

Mr. THOMSON (Observer, World Meteorological Organization), speaking at the invitation of the PRESIDENT, explained that it was often necessary to draw maps based on an equal area projection and to use the Mercator projection. The amendment of Gabon would meet his point.

The PRESIDENT asked if the amendment was acceptable to the Chairman of Committee III.

Mr. BONNET-DUPEYRON (France), Chairman of Committee III, accepted that amendment. He moved that the report of Committee III as a whole, with the amendment just proposed, be adopted by the Conference.

The PRESIDENT stated that by adopting the report the Conference also adopted the draft resolution on co-operation between specialists in and producers of topical maps.[10]

Dr. WASSEF (United Arab Republic), Mr. TARRADE (Upper Volta), Mr. TRAIZET (Madagascar) and Mr. DE MASSON D'AUTUME (Gabon) seconded the adoption of the report as amended.

The report of Committee III, as amended, was unanimously adopted.[11]

Report of Committee IV (E/CN.14/CART/104)

Mr. OKEC (Uganda), Chairman of Committee IV, presented the draft report.

Mr. WILLIAMS (Kenya) pointed out that it had been agreed that the English rendering of "transcription", appearing in the second and third paragraphs of item 3 on page 2, should be "written form".

It was so agreed.

Mr. TARRADE (Upper Volta), Rapporteur of Committee IV, pointed out that document E/CN.14/CART/63

[8] For the full text of the report, as adopted, see *United Nations Regional Cartographic Conference for Africa*, vol. 1, *Report of the Conference*, (Sales No.: 64.I.2), p. 12, annex I.

[9] For the full text of the report, as adopted, see *United Nations Regional Cartographic Conference for Africa*, vol. 1, *Report of the Conference* (Sales No.: 64.I.2), p. 12, annex II.

[10] For the text of the resolution, as adopted, see *United Nations Regional Cartographic Conference for Africa*, vol. 1, *Report of the Conference* (Sales No.: 64.I.2), p. 10, resolution 18.

[11] For the text of the report, as adopted, see *United Nations Regional Cartographic Conference for Africa*, vol. 1, *Report of the Conference* (Sales No.: 64.I.2), p. 14, annex III.

which had inadvertently been omitted, should be added to the list of documents received.

Mr. OKEC (Uganda), Chairman of Committee IV, supported by Dr. WASSEF (United Arab Republic), Mr. SAWYERR (Liberia) and Mr. SKUSE (Sierra Leone), moved the adoption of the report as amended.

The report of Committee IV, as amended, was unanimously adopted.[12]

ADOPTION OF THE REPORT OF THE CONFERENCE
(E/CN.14/CART/99 and Corr.1)

The PRESIDENT invited the Conference to consider its draft report. He stated that this provisional text would be completed taking into account the current proceedings and the final editing for official publication would be made in accordance with the procedure and practice followed by the United Nations.

Mr. DIAGNE (Senegal), Rapporteur, supported by Dr. WASSEF (United Arab Republic), Mr. SAWYERR (Liberia), and Mr. TARRADE (Upper Volta) moved the adoption of the draft report.

The draft final report was unanimously adopted.[13]

Closure of the Conference

The PRESIDENT said he had been greatly honoured by his election as President of the Conference. He thanked all the representatives, whose help and co-operation had turned a potentially difficult task into an easy one.

Dr. WASSEF (United Arab Republic) proposed a vote of thanks to the President and the Executive Secretary.

Mr. SAWYERR (Liberia) seconded the proposal. He had been greatly impressed by the able manner in which the President, the Executive Secretary and the Rapporteur had conducted the session, and also by the efficient working of the Committees.

Admiral KARO (Observer, United States of America), expressed his appreciation and that of the other observers of the welcome they had received as participants in the Conference. He looked forward to meeting the representatives on future occasions.

Vice-Admiral FRANCO (Observer, IHB), thanked the members of the Conference for adopting the resolution on hydrography.

The EXECUTIVE SECRETARY thanked all the members of the Conference for their co-operation and understanding. He was particularly grateful to the President for his guidance, to the Rapporteur and to the officers of the Committees.

He paid a warm tribute to the Kenya Government and its officials for their invaluable help during the Conference.

The PRESIDENT declared the First United Nations Regional Cartographic Conference for Africa closed.

The United Nations Regional Cartographic Conference for Africa was closed on 12 July 1963, at 12 noon.

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[12] For the text of the report, as adopted, see *United Nations Regional Cartographic Conference for Africa*, vol. 1, *Report of the Conference* (Sales No.: 64.I.2), p. 15, annex IV.

[13] For the text of the report, see *United Nations Regional Cartographic Conference for Africa*, vol. 1, *Report of the Conference* (Sales No.: 64.I.2).

Part II

REPORTS BY GOVERNMENTS AND INTERNATIONAL ORGANIZATIONS ON THEIR ACTIVITIES FOR THE AFRICAN CONTINENT

AGENDA ITEM 6

Review of cartographic activities in Africa

(See also agenda item 14)

CARTOGRAPHIC ACTIVITIES IN THE CONGO (LEOPOLDVILLE)[1]

Introduction

In 1962 the work of the Institute became more regular, although still remaining below its normal level because of difficulties in obtaining supplies of essential products, spare parts, and so on.

This year for the first time the Geographical Institute of the Congo participated in several international conferences including the Colloquy and 4th Meeting of the Committee for the Establishment of CCTA/CSA Maps at Salisbury, the Munich Photogrammetric Week and the Bonn Conference on the *International Map of the World on the Millionth Scale.*

The appointement in the near future of our trainees, who will be able to act as heads of topographical missions, and the recruitment of a technician responsible for aerial surveys, give us every reason to expect the Institute's work to expand in 1963.

Chapter I. Division of General and Administrative Services

. . .

Chapter II. Division of Geodesy and Topography

(C) WORK

I. *Work on the ground (see also plates 1, 2, 4).*

Completed

(*a*) Planimetric control and trigonometric levelling: 6 fill-in points in the Lukula (Lower Congo) region.

(*b*) General levelling: nil.

A sustained effort was made, however, to re-establish a levelling mission which would have operated in Kwilu and in the Port-Francqui Territory and Tshikapa.

After a reconnaissance carried out in May it was found that the damage to the demarcation of levelling lines was more extensive than had been allowed for on the basis of information obtained in 1960; thus, no marking point was found west of Port-Francqui, and the same situation prevailed to the East of that locality (line HO).

Moreover, we have had to recognize that it was premature to despatch the planned mission because of the lack of supplies on the spot and because of the difficult working conditions the staff might still encounter in certain regions.

(*c*) Equipment for photogrammetry

22 points for cartography-topography on the scale 1:50,000 (RR 222—East of the Boma-Lukula axis).

6 points for planimetric cartography on the scale 1:100,000 (Zones 7 and Extension in R.U.).

Planned

(*a*) Lower-Congo: completion of equipment for the topographical map on the scale 1:50,000 (RR 216 to the north of the 5th parallel to the west of the Leopoldville meridian).

(*b*) Leopoldville region: regional precision levelling cross-overs, completion survey of trigonometric control, occasional network for cartography.

(*c*) Possible work according as the situation improves.

(*d*) For cartographic networks by absolute determinations, the courses given by a technician to 6 apprentice geographers will continue during a large part of the year.

II. *Work on the Computations and Publications Section*

Computations made (completed in 1962) see plate 3:

(a) *Definitive* (based on the 30th meridian, datum Arc 1951):

1. Planimetric adjustment (principal chain) computations of planimetric and geometric co-ordinates of the Congolese Arc of the 6th parallel.
   Publication of the results is in process.
2. Planimetric adjustment of the Graben and 3° S Transversal Chain (liaison with the chain of the 30th meridian).
   Computation of co-ordinates X, Y in the projection.
3. TZGL network (Zone of the great Kivu-Maniema Lakes) planimetric adjustment and computation of the X, Y co-ordinates in the projection.
4. Main controls and fill-in of Itombwe (CFL), Kiliba-Ulindi (Forces) and South-Kamituga (MGL):
   Planimetric adjustment and computation of X, Y co-ordinates in the projection.

(b) *Provisional:*

1. River control Boma down-stream—Banana.
   Planimetric adjustment with computation of co-ordinates in the projection.

[1] The original text of this paper, submitted by the Congo (Leopoldville), under the title "Activités cartographiques au Congo (Léopoldville)", appeared in French as document E/CN.14/CART/49.

Compilation of the list of co-ordinates.

2. Control of Western region, situated between the 1st and 2nd Transversals of Ruanda-Urundi.
   Same work as above.

(c) *Computations for photocartography:*

Computed control points: 181.
Transformation of co-ordinates: 146 points.

Computations in progress (1962-63):

(*a*) Altimetric adjustment of the Lower-Congo network.
Computations of altitudes.

(*b*) Regional control of Bukavu.
Definitive planimetric adjustment of the main figures.
Computation of the X Y co-ordinates in the projection.
Publication of results.

Computations planned in 1963:

A. *Definitive computations*

(*a*) Planimetric adjustment of the main network and the secondary network of the NORTH-KIVU bounded by the 1°N and 1°S parallels.
Computation of co-ordinates in the projection.
Publication of results.

(*b*) Main and secondary control of Ruzizi:
Planimetric adjustment.
Computation of co-ordinates in the projection.
Publication of results.

(*c*) Planimetric adjustment of the secondary controls:
(1) In the North-Kivu.
(2) In the Lower-Congo.
(3) In the TZGL network.
(4) In the Bukavu-region.

B. *Current transformation computations of co-ordinates and control points for the Photocartography Department.*

Chapter III. Photocartography Division

I. Aerial surveys

C. *Work*

C1—*Aerial work:* was not resumed in 1962 owing to:
The lack of suitable flying equipment;
The economic situation which did not permit renewal of the contract of hire which existed previously between Sabena and the IGC.

The photographic cover has not been modified since 1 January 1961. Its adds up to 85 per cent of the total area of the country and is shown on the map of the photographed regions (plate annex 1).

C2—*Ground work:* the establishment of new cover diagrams, drawn on the basis of the new aerial surveys completed, had to be interrupted because no aerial surveys have been made since January 1961. The team responsible for this work has nevertheless carried out the following work:

(*a*) Checking and representation on 1:500,000 diagrams by province:
Of continuity solutions appearing locally in the photographed zones, either through the absence of photographic overlap between strips or through excessive cloud;
Of the common parts between neighbouring strips which do not present an adequate lateral overlap.

(*b*) Rectification of some cover diagrams.

(*c*) Modification of 40 of the cover diagrams previously established.

(*d*) Re-sketching of aerial photographs of certain blocks the previously established tracings of which were incomplete or had deteriorated.

II. Cartography

C. *Work*

Cartographic interpretation work of the aerial cover is hereunder by category and given again in detail in the annexes.

C1. *1st stage cartography*

Compilations—small scale stereo master-copies (annex 1 and plates 1*a*, 1*b* and 1*c*).

C1.1 *Scale tracings of photographs*
New: 29,000 km².

C1.2. *Master-copies on the scale 1:200,000* (plate 1*a*)
New: 42,240 km².
Remodelled: on tracing: 45,400 km².
on paper: 54,625 km².

C1.3. *Stereo master-copies on the scale 1:1,000,000 by* province (plate 1*b*) on the scale 1:3,000,000 for the whole Congo (plate 1*c*)

C2. *2nd stage cartography:* simplified plotting (annex II and plate 2)

C2.1. *Systematic work:*

Planimetric master-copies on the scale 1:50,000:
Completed as far as the drawing stage: 52,000 km².
Completed as far as the radial triangulation stage: 47,000 km².
Completed as far as plotting on the instruments stage: 3,500 km² (R.U.-R.S. 78).

C3. *3rd stage topographical cartography:* topographical plotting (annex III and plate 3).

Topographical master-copies:
In progress: 15 km² on the scale 1:5,000
12,600 km² on the scale 1:25,000

Planimetric master-copies on the scale 1:50,000 plotted on instruments: 3,500 km² (R.U.-R.S.78) (see 2.1).

C4. *Mosaics* (plate 4)

In view of the high cost price and low sale of this work it has been suspended. Only specially demanded work will be performed.

C5. *Drawing:* The cartographic drawing office has produced several works of which the principal ones are listed in annex IV.

C6. *Collation and arrangement of base maps* (annex V)

All these drawing works are edited by the Bureau du collationnement et des bases (Collation and Base Maps Office).

In addition, this Office keeps up to date the filing and index of basic documents: geodetic, topographic, gravimetric, photographic, stereo records and their derivatives, base maps of territorial boundaries, toponymy, specific information and conventional representation, and the filing of cartographic master-copies selected at the drawing stage. The records relating to this documentation are filed and an index of them is kept up to date.

The non-cartographic documents printed by the IGC are also indexed and filed.

C7. *Cartographic reproduction:* photo engraving and printing (annex VI)

The printing shop consists of:

(*a*) Two offset machines on which the following were printed:

	Number of runs through the press
1. *Documents in one colour*	
19,330 plans, maps and sketches (10 different documents)	4,000
54,500 miscellaneous formularies	11,000
400 pamphlets (1 document)	3,400
2. *Documents in two colours*	
500 maps (12 different documents)	800
3. *Documents in three colours*	
6,800 maps (21 different documents)	29,000
4. *Documents in four colours*	
4,840 maps and plans (8 different documents)	21,800
5. *Documents in five colours*	
28,450 maps and sketches (11 different documents)	18,000
6. *Documents in six colours*	
1,500 maps (3 different documents)	9,000
7. *Documents in seven colours*	
1,000 maps (2 different documents)	7,000
8. *Documents in eight colours*	
250 maps (1 document)	2,000
9. *Documents in ten colours*	
500 maps (1 document)	5,000

Total quantities:

63,170 plans, maps and sketches
54,500 formularies
400 pamphlets.

This production which relates to 60 different cartographic documents and to various collections of formularies, has necessitated 111,000 runs for both offset presses, i.e., approximately 200 runs per machine per working day.

(*b*) *A hand typographic press*, permanently used for the printing of covers for pamphlets and various collections of formularies.

(*c*) *A photo engraving laboratory* in which the work listed in annex VI was performed.

C8. *Photographic laboratories*

The following work was performed:

On the pneumatic slide

Photoprints of 369 mosaics for the sales service
446 m^2 of photomechanical and photocopied reproductions.

On ordinary printers

Photoprints of 22,626 contact prints
5,356 transparencies
4,964 counterparts.

On the reproduction machine (Repronar)

Reductions of 95 plates
Reductions of 7 assemblies
Enlargement of 56 plates.

On the rectifier (Zeiss)

Photos set to scale, for mosaic: nil. (N.B. The preparation of mosaics has been suspended and is only done by special order.)

Photographic enlargements of 69 documents.

On the Hadego machine

Production of 161 films for toponymy and cartographic texts. (N.B. This machine was out of order for several months because of the lack of adequate lighting tubes.)

Since October 1962 production has been slowed down owing to the lack of stripping film which was ordered but not delivered.

On the "Kartolux" machine

Production of 2 films comprising the toponymy for two cartographic plates.

C9. *Trials—Studies*

Certain trials and studies have been made at the drawing stage:

The application of various procedures for altimetric representation: shadings—hypsometric tints—feature curves. The procedure of representing relief by shading could be applied in the future in the preparation of certain maps, for regions where the altimetry is not precisely known. Two draughtsmen were given training in this special work at a course they followed at the Institut Géographique National. The "Scribing" procedure (engraving on transparent support) was tested and found satisfactory from the point of view of representation, particularly of road networks, railways and contours. Two draughtsmen were introduced to this new method when they followed a course at the Institut Géographique National.

E3. *Work*

The long-term cartographic programme planned as one of the projects of the Second Ten-Year Plan will remain in force and may be executed as a priority for:

(1) The regions at present covered by aerial photography and by a "ground" network suitable for the cartography planned;

(2) The other regions according as circumstances permit the execution of the photographic cover and the "ground" network suitable for the cartography planned.

This programme comprises:

Small-scale *planimetric* cartography (1st stage: compilation) which may be conducted in terms of the interpreted photographic cover;

Medium-scale *planimetric* cartography (2nd stage: simplified plotting), which may be conducted in terms of the existing or possible future "ground" network.

Small-scale *topographical* cartography, including:

(*a*) The sheet line map of the world on the 1:1,000,000 scale in Lambert's orthomorphic projection;

(*b*) The ICAO map on the 1:1,000,000 scale for which the world map will serve as a base, with aeronautical information overprinted;

(*c*) The administrative and political map of the Congo on the scale 1:3,000,000;

Medium-scale *topographical* cartography as there is a topographical mission operating in the Lower Congo, this cartography may be continued in the future.

Large-scale *topographical* cartography (urban centres) cannot be undertaken until circumstances permit "ground" missions to function normally.

ANNEX I

1st Stage Systematic Cartography : compilations (plate 1*a*)

(See plates 1a, 1b and 1c)

No. of the compilation	*Region*	*Area covered in km²*
(*a*) Tracings of compilations (on the scale of the photos)		
C.49	Inongo–Lokolama–Oshwe	29,000
	TOTAL	29,000
(*b*) New compilation master-copies on the scale 1:200,000		
C.72*b*. . . .	Stanleyville–Bafwasende (2nd part)	17,820
C.49	Inongo–Lokolama–Oshwe	24,420
	TOTAL	42,240
(*c*) Remodelled compilations		
	(1) On tracings	
C.75*b*. . . .	Befale–Djolu	45,400
	TOTAL	45,400
	(2) On thick paper on the scale 1:200,000	
C.75*b*. . . .	Befale–Djolu	45,400
C.73	Bafwasende (connexion with R.S. 66) . .	9,225
	TOTAL	54,624
(*d*) Stereo master-copy on the scale 1:1,000,000: new master-copies for each province on Mercator projection (plate 1*b*) The existing stereo master-copies, compiled before 1962, by reduction of compilations and plottings, have been completed by incorporating new cartographic bases compiled in 1962 by these methods		
(*e*) Stereo master-copies on the scale 1:3,000,000: new master-copies for the map of the whole Congo on Mercator projection (plate 1*c*) The establishment of master-copies on the scale 1:3,000,000 on Mercator projection is achieved by reduction of the pantograph, based on master-copies on the scale 1:1,000,000 as and when the latter are compiled		

ANNEX II

2nd Stage Systematic Cartography, Systematic Work

(See plate 2)

No.	*Region*	*Area in km² covered by radial triangulation*	*Area drawn*	*Scale*	*Precision*
RS 61. . . .	Kwango–Est	(In 1961)	24,000 km²	1:50,000	1:100,000
RS 70[a](1) . .	Wamba–Mambasa	(In 1961)	21,000 km²	1:50,000	(N.1: 100,000) (S.1: 200,000)
RS 78 (2) . .	Ruanda-Urundi (zones 1 to 6)	13,000 km²	7,000 km²	1:50,000	1:100,000
RS 54 . . .	Businga–Banzyville	24,000 km²	—	1:50,000	1:200,000
RS 56 . . .	Lisala	10,000 km²	—	1:50,000	1:200,000
	TOTAL	47,000 km²	52,000 km²		

(1) The RS 70[a] plotting on the stereotope had been suspended to give priority to RS 78 (R.U.). At present, plotting on instruments is complete, but 5 plates out of 28 have still to be drawn in accordance with the stereotope master-copies.

(2) About one-half of the plotting and drawing was done by A6, the other half by stereotope. Contours have been transposed on to these planimetric plates on the basis of contours of the topographic plates of R.U. printed on the scale 1:100,000 (1936 edition).

ANNEX III

Topographical cartography at the third stage

(See plate 3)

Area	*Requested by*	*Scale of photographic survey*	*Surfaces in km²*	*Number of plates*	*Scale*	*Comments*
		1. WORK COMPLETED				
Ruanda-Burundi RS 78	R.U.	1:30,000	3,500	5	1:50,000	
		2. CURRENT WORK				
Kisantu-Kindopolo (South) Road [a] . . .	TP/G.C.	1:20,000	15		1:5,000	
Blocks 9-11 Lower Congo	G.C.	1:40,000	4,400	22	1:25,000	1:50,000 precision
Block 3 South Lower Congo	G.C.	1:40,000	2,500	13	1:25,000	ditto
Block 1 North Lower Congo	G.C.	1:40,000	1,500	8	1:25,000	ditto
		3. FUTURE WORK				
Blocks 8-10 Lower Congo	G.C.	1:30,000	4,200	21	1:25,000	ditto

[a] This plotting had to be interrupted because it was found necessary to carry out further ground surveys, and this was done in 1962.

ANNEX IV

Cartographic drawings

The Drawing Office has carried out a great deal of work, including, in the order of importance:
Preparation of new cartographic sheets;
Rearrangement, revision and finalizing of the existing cartographic sheets;
Special work for public agencies and the private sector.

The main work is outlined below:

(1) Analysis of simplified plotting sheets and of compiling for the preparation, rearrangement or revision of territorial sheet-line maps.

(*a*) Territorial maps on the scale of 1:200,000 (Congo)

Province	*Number of territories*					
			Revised sheets for			
	New sheets	*Rearranged sheets*	*A.T. information*	*R.C. and levelling line*	*Numbering of photos*	*Miscellaneous*
Leopoldville	—	—	3	1	2	3
Equateur	1	—	—	—	—	—
Orientale	2	—	3	—	—	3
Kivu	—	—	2	—	—	2
Katanga	—	—	1	—	—	1
Kasai	—	1	2	1	1	2
TOTAL	3	1	11	2	3	11

N.B. *Repère de canevas* = R.C. (geodetic control mark).

Miscellaneous: usually comprises revision for the classification of roads, airports, parcelling centres, and for technical service notes on cartography.

N.B. In the case of work connected with the notation of photo numbers, geodetic control marks and identification marks for levelling lines, the figures given in the table do not include figures from the new sheets, on which work will have to be done.

(*b*) *Road and Administrative Maps*, on the scale of 1:1,000,000, by province.
New maps combining the Road Map and the Administrative and Political Map, by direct Mercator projection

Province	
Orientale	completed
Leopoldville	nearing completion
Kivu	in progress
Kasai	in progress
Katanga	in progress

(2) Finalizing and analysis of the simplified and standard plotting sheets with a view to preparing, rearranging or revising maps with *systematic sheet lines* (in accordance with geographical lines: square degrees and subdivisions).

1:25,000 (topographical) (7′30″ × 7′30″)	2-colour separation: 8 plates in progress (RSA 108 and 109) Drawing of colour selections (7 colours) 16 plates completed 21 plates in progress
1:50,000 (planimetric) (15′ × 15′)	Provisional drawing on astralon: 3 plates RS 68 (R.U.) 13 plates RS 78 (R.U.) 39 plates Drawing of colour selections (6 colours) 14 plates concluded 20 plates in progress
1:50,000 (topographical) (15′ × 15′)	Final plates (7 colours) 3 plates concluded 1 plate in progress
1:100,000 (planimetric) (30′ × 30′)	Final plates (6 colours) 3 plates concluded
1:100,000 (planimetric) (30′ × 30′) (for R.U.—R.S. 62 and 68)	Final plates (4 colours) 1 plate concluded 1 plate in progress
1:200,000 (planimetric) (1° × 1°)	Final plates (3 colours) 3 plates concluded 3 plates in progress

(3) *General Maps (1:3,000,000 and 1:8,000,000)*

Appended to Annual Report for 1961: 9 plates on the scale of 1:8,000,000.

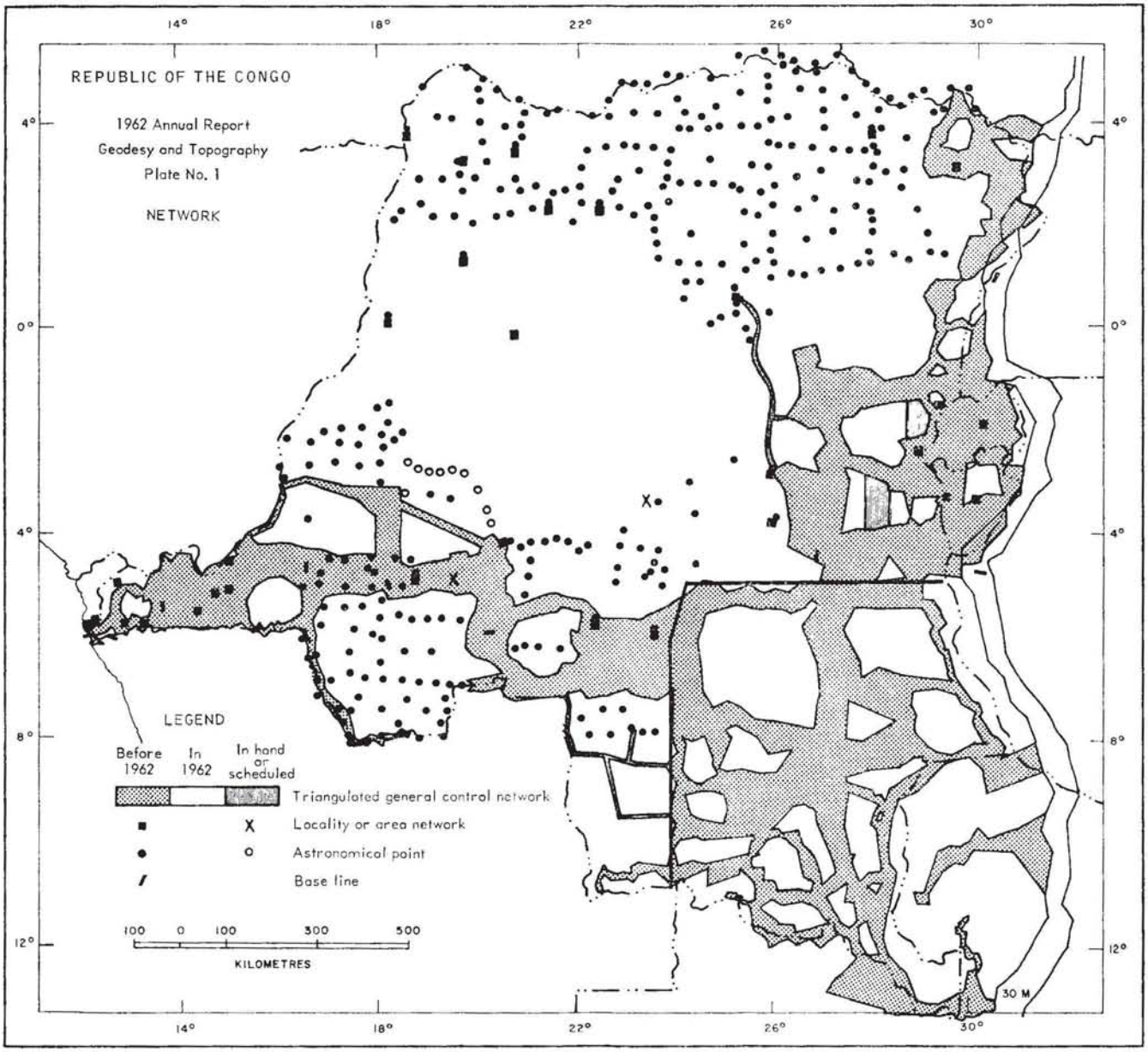
(4) *Miscellaneous drawings and status maps*

(a) *For the Geographical Institute of the Congo = IGC*

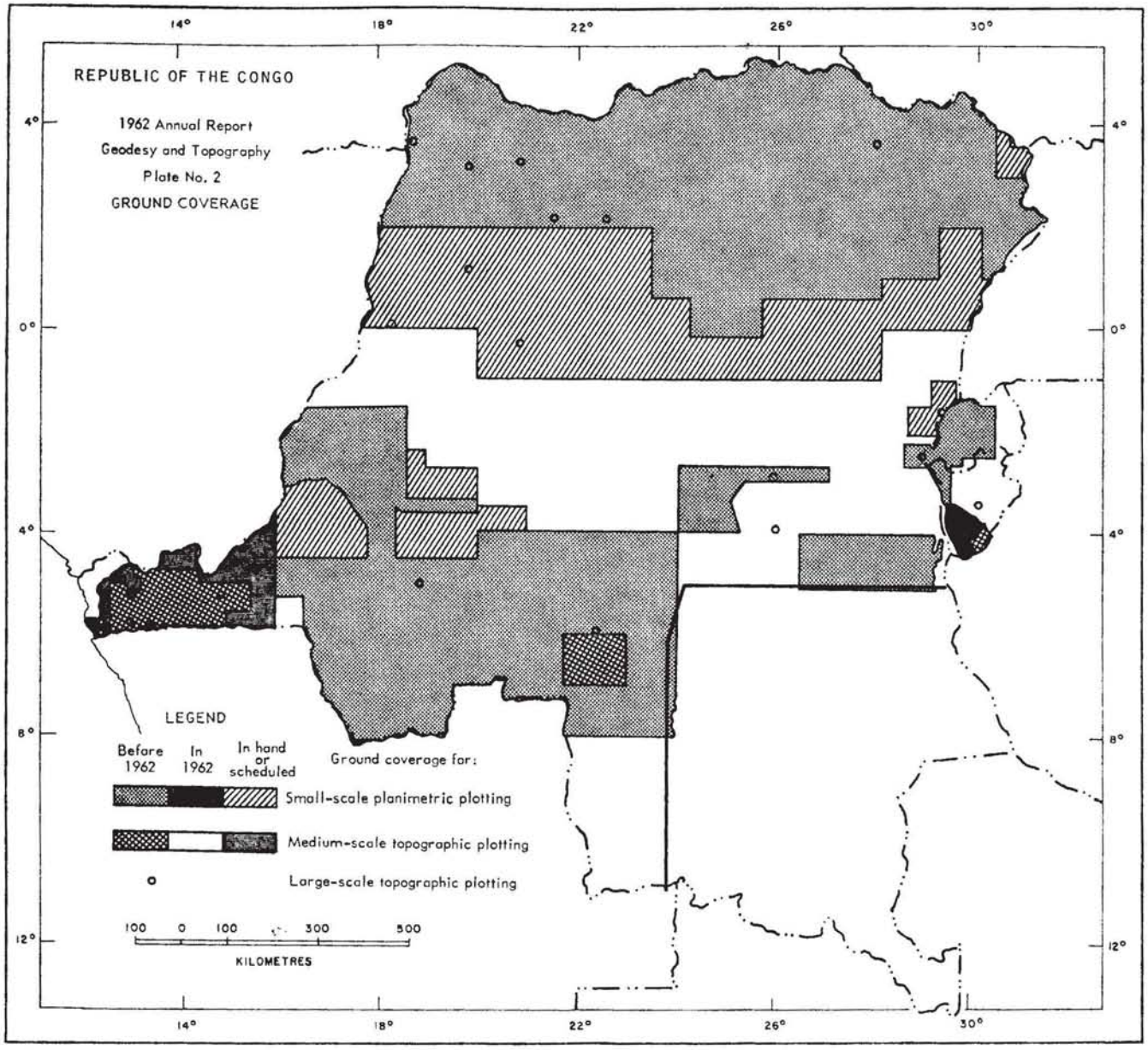
1. Gravity map of the Congo, on the scale of 1:3,000,000, concluded.
2. Map of the sky.
3. Programme for the 1960-1969 decade, on the scale of 1:3,000,000.
4. Administrative map of the new Provinces (provisional edition), on the scale of 1:3,000,000.
5. Ruanda-Burundi territory, on tracing paper.
6. Revision of aeronautical information handbooks (in progress).
7. Study of conventional signs, on film, adopted at the Bonn Conference.
8. IGC organigram.
9. Photocartographic organigram.
10. Project for parcelling construction (IGC).
11. Plan for the construction of a drafting room (IGC).
12. Pay slips (IGC).

(b) *For public agencies and the private sector*

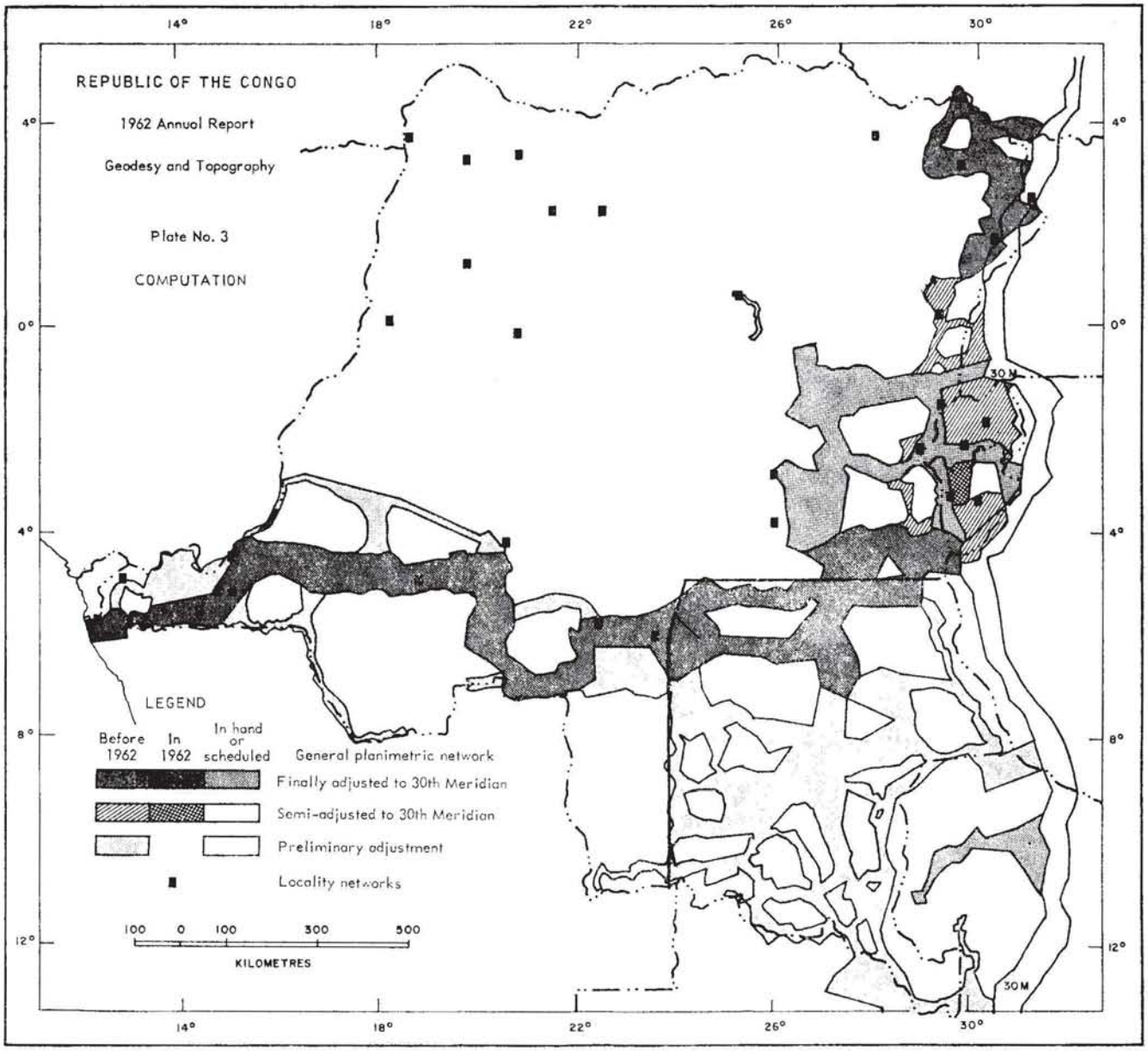
1. Fourteen aeronautical landing charts, on the scale of 1:25,000 (concluded).
2. Twelve aeronautical landing charts, on the scale of 1:25,000 (in progress); work suspended owing to shortage of thick paper for drawing of sheets.
3. Organigram of the Ministry of Planning and Economic Co-ordination.
4. Structural organigrams 1, 2, 3 and 4 of the Directorate of Planning.
5. Five maps of the Congo, on triplex, for the Ministry of Public Health.
6. Map showing the organization of the new Provinces (provisional edition), on the scale of 1:3,000,000; twelve maps to be coloured.
7. Drawing of map of Africa, on tracing paper.
8. Organigram of the Ministry of Justice.
9. Hotel Memling site plan.
10. Editing of Shell road map.
11. Schematic city plan for Administration (ONUC).
12. Yard tape, on astralon (ONUC).
13. Regional map of Elisabethville, on the scale of 1:50,000 (ONUC).
14. Organigram of economic and social planning studies, on astralon.
15. Red Cross posters.



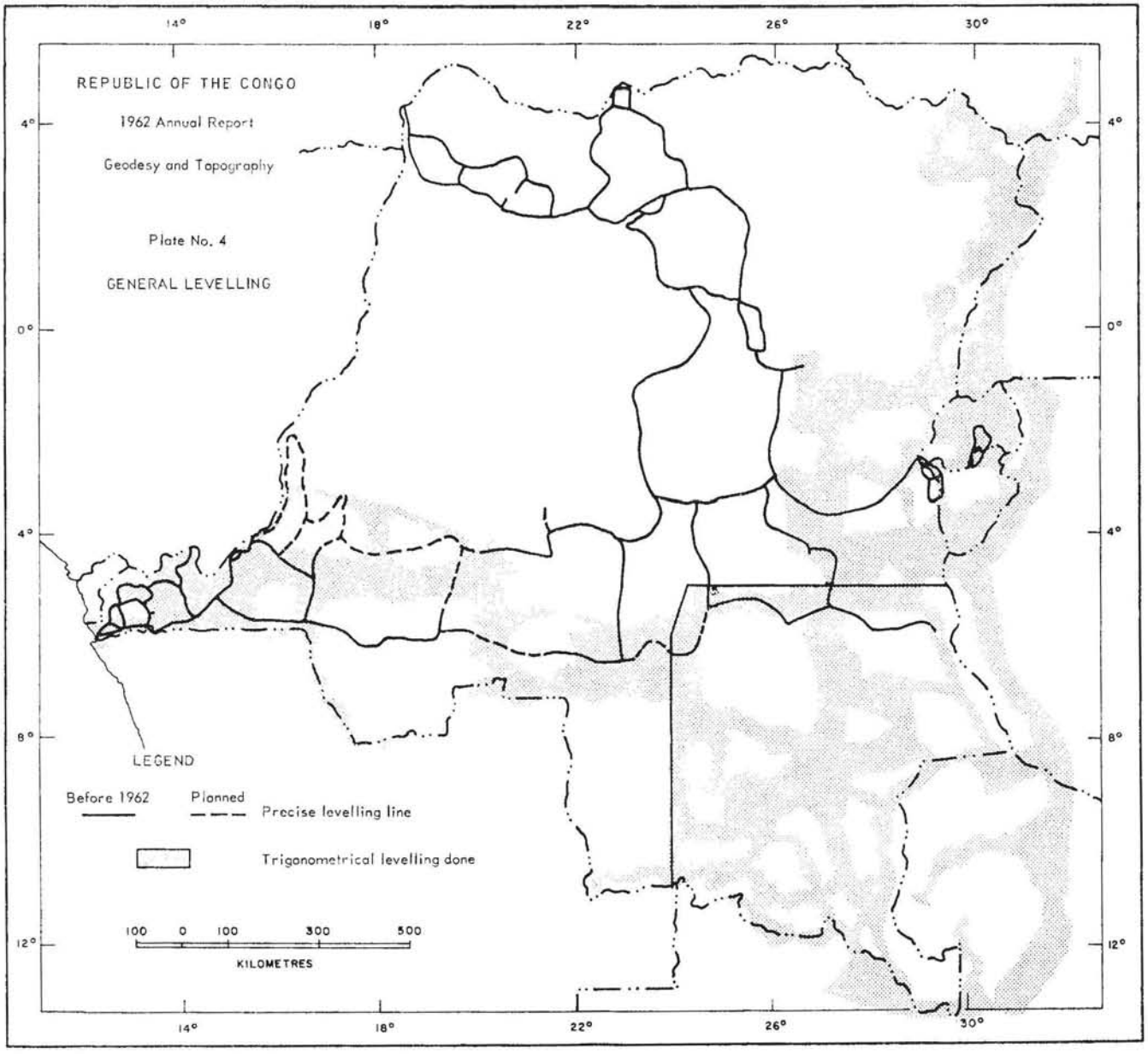
Republic of the Congo : geodesy and topography: network



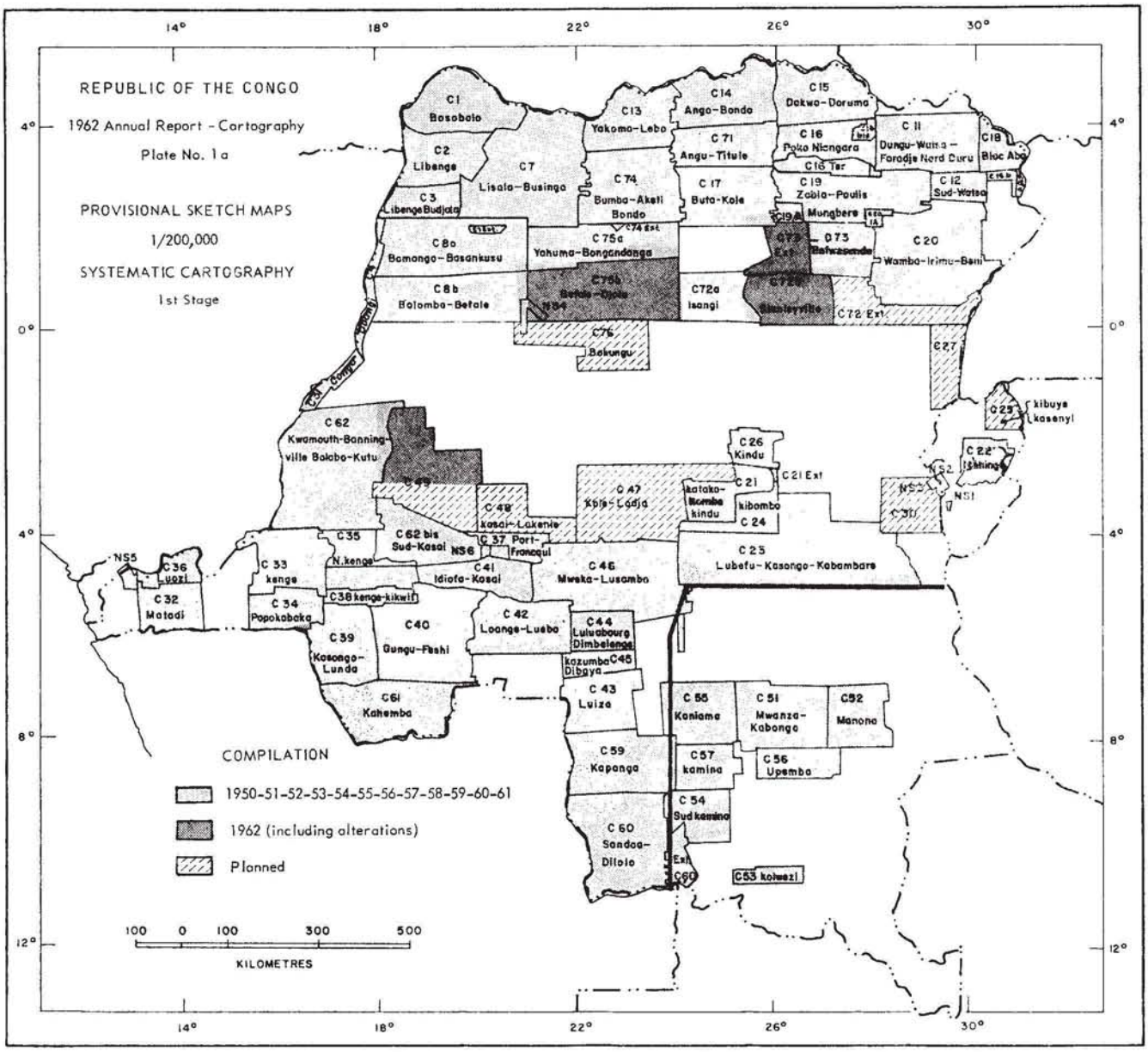
Republic of the Congo: geodesy and topography: ground coverage



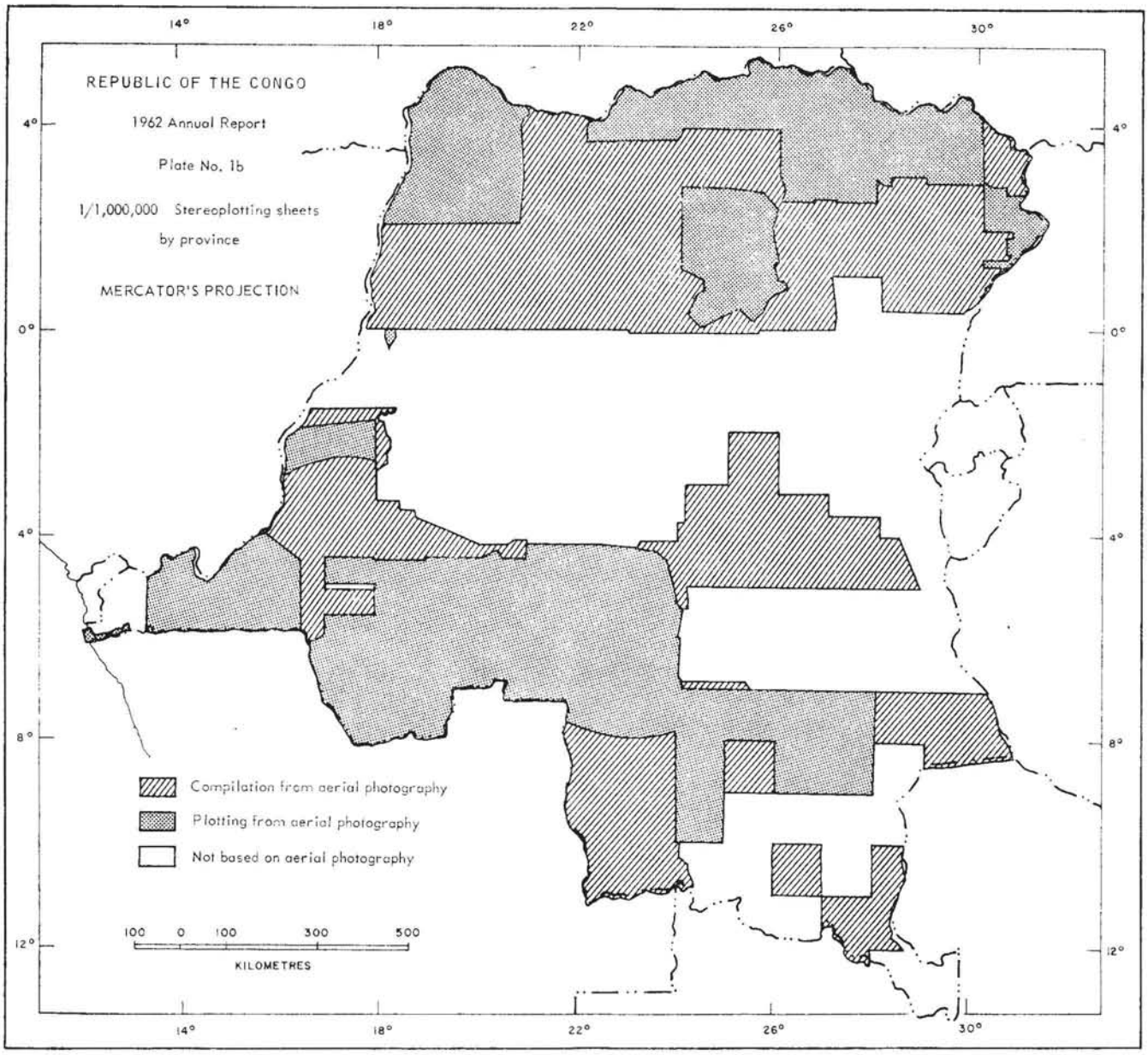
Republic of the Congo: geodesy and topography: computation



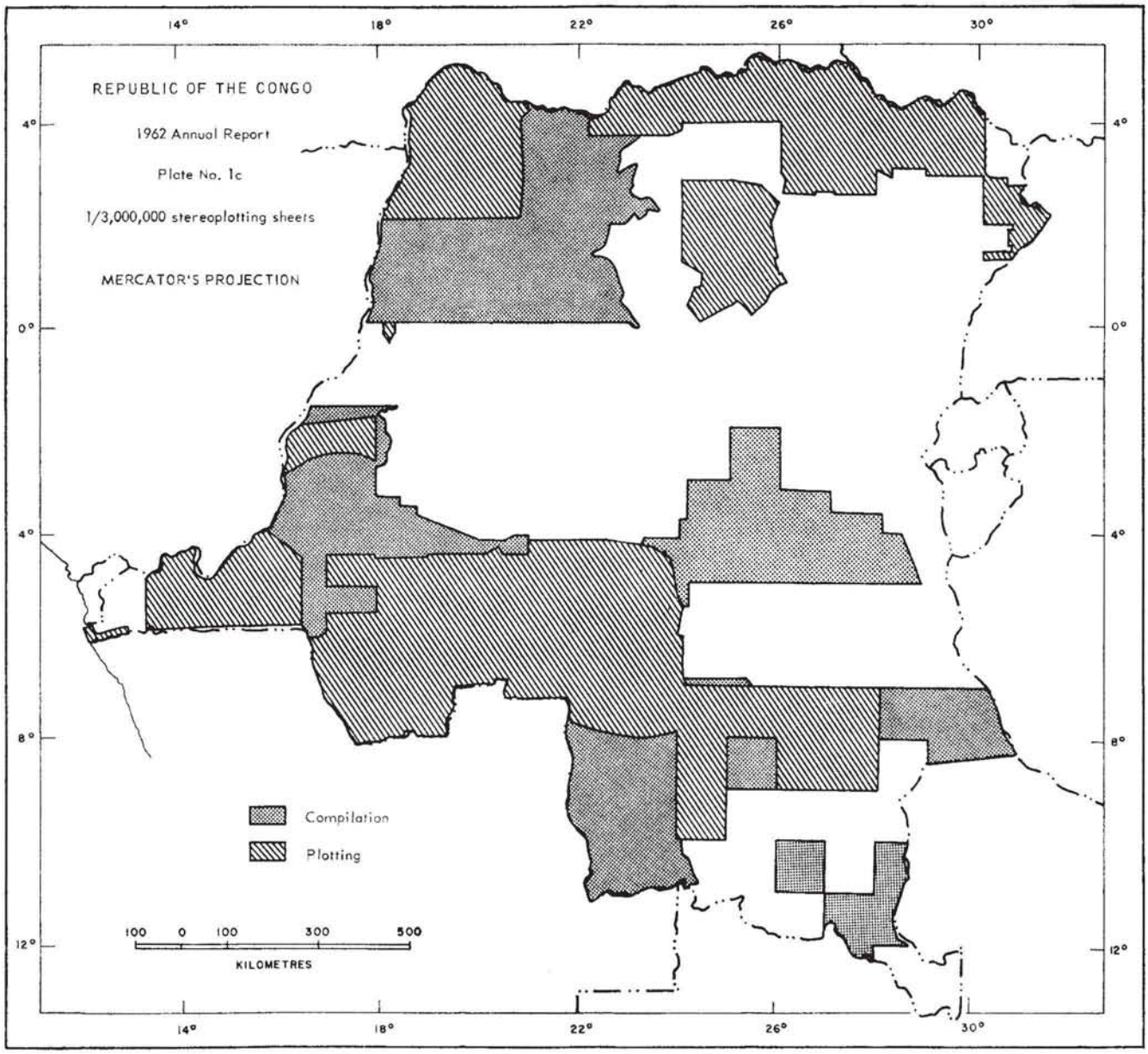
Republic of the Congo : geodesy and topography : general levelling



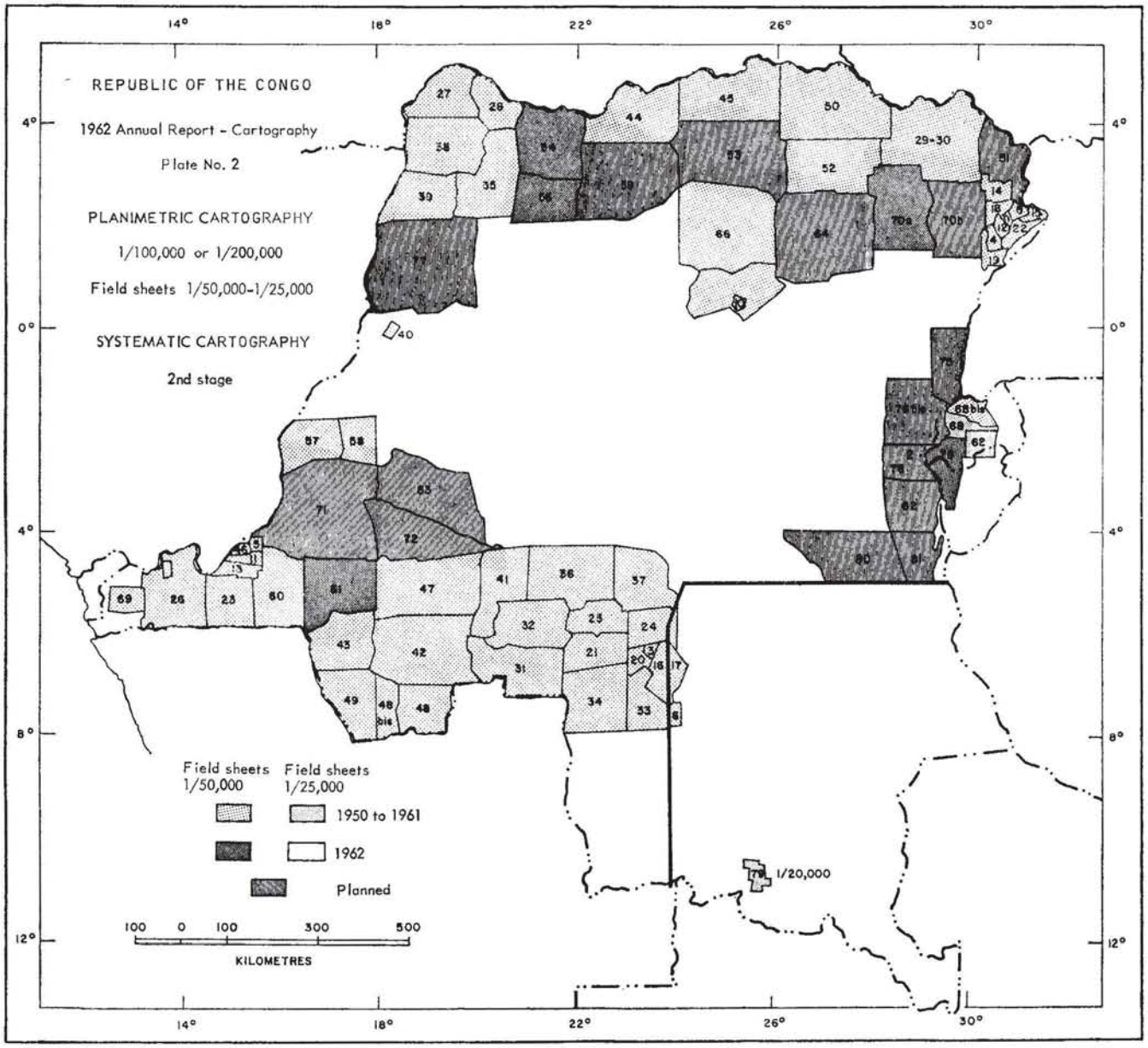
Republic of the Congo: cartography: provisional sketch maps 1:200,000
Systematic cartography 1st stage



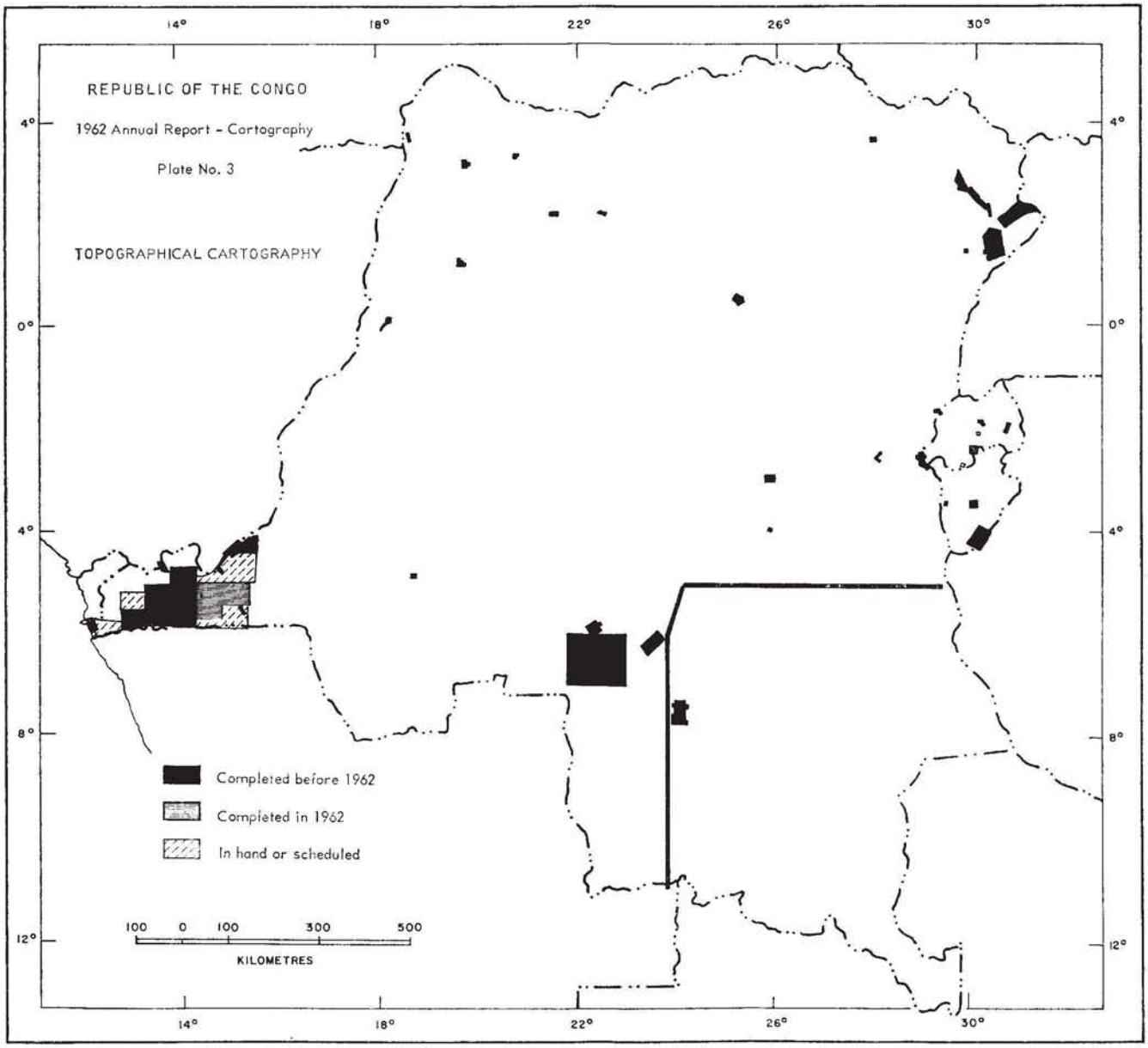
Republic of the Congo: cartography: 1:1,000,000 stereoplotting sheets



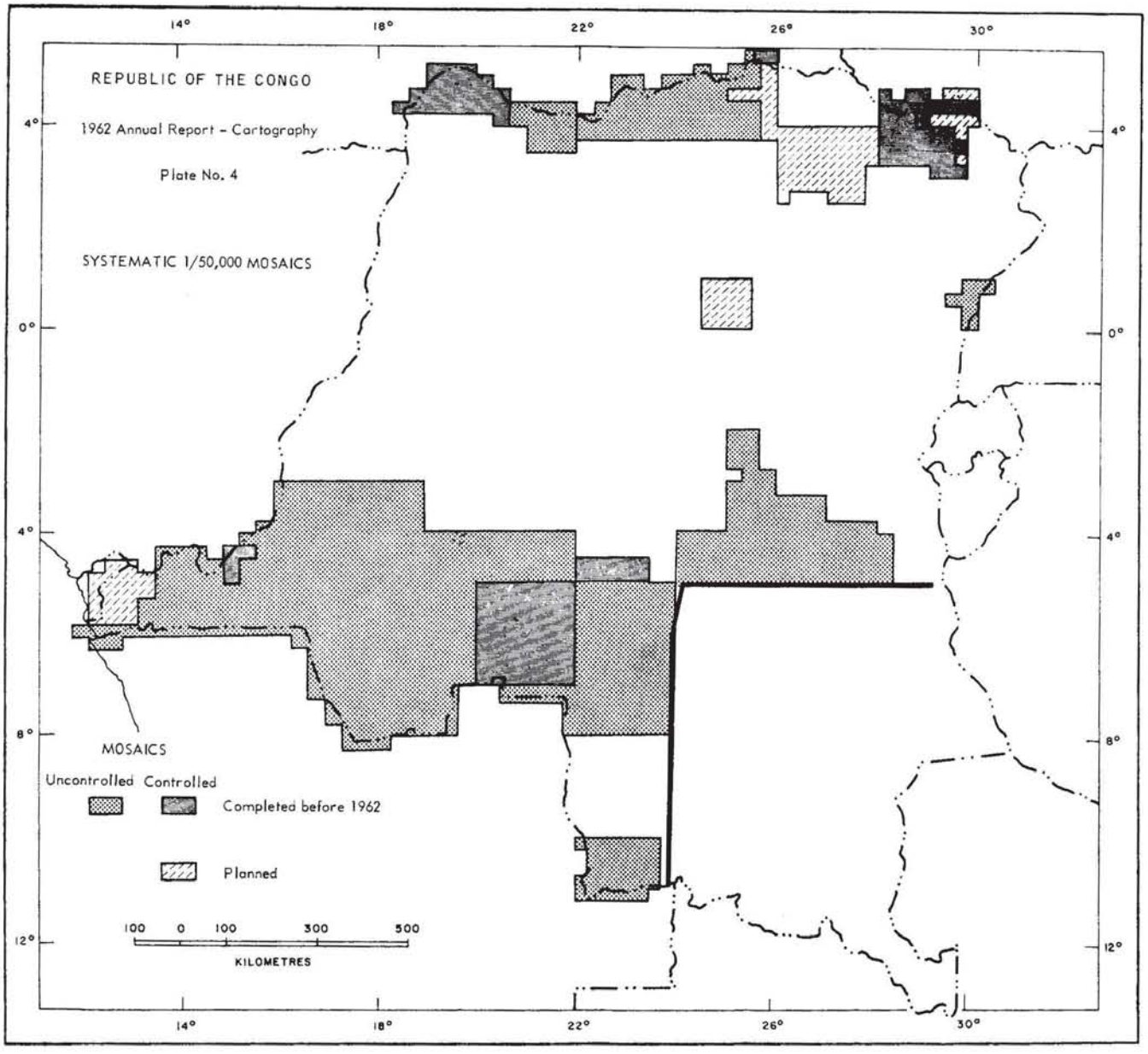
Republic of the Congo: cartography: 1:3,000,000 stereoplotting sheets



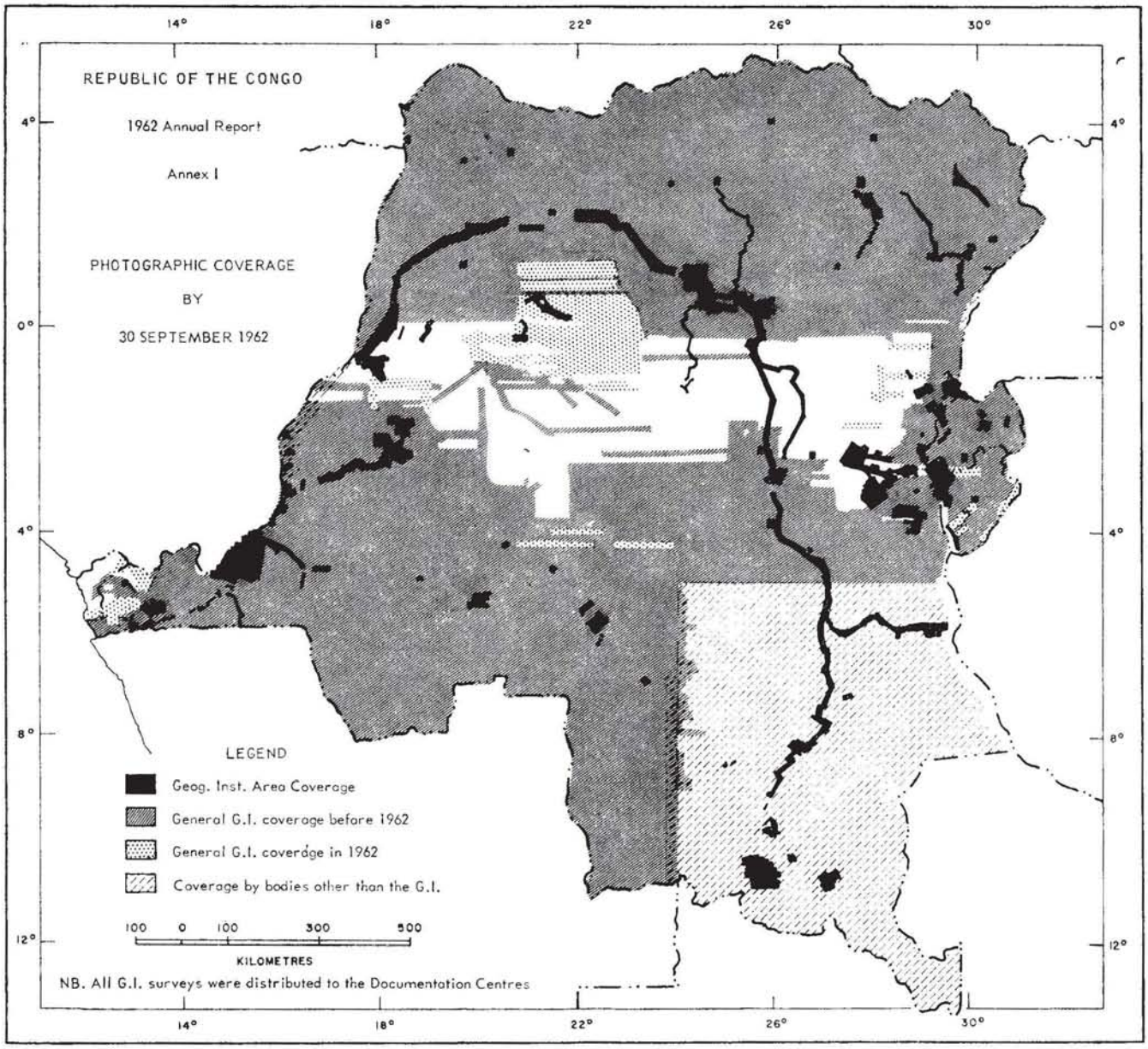
Republic of the Congo : cartography : planimetric cartography
Systematic cartography 2nd stage



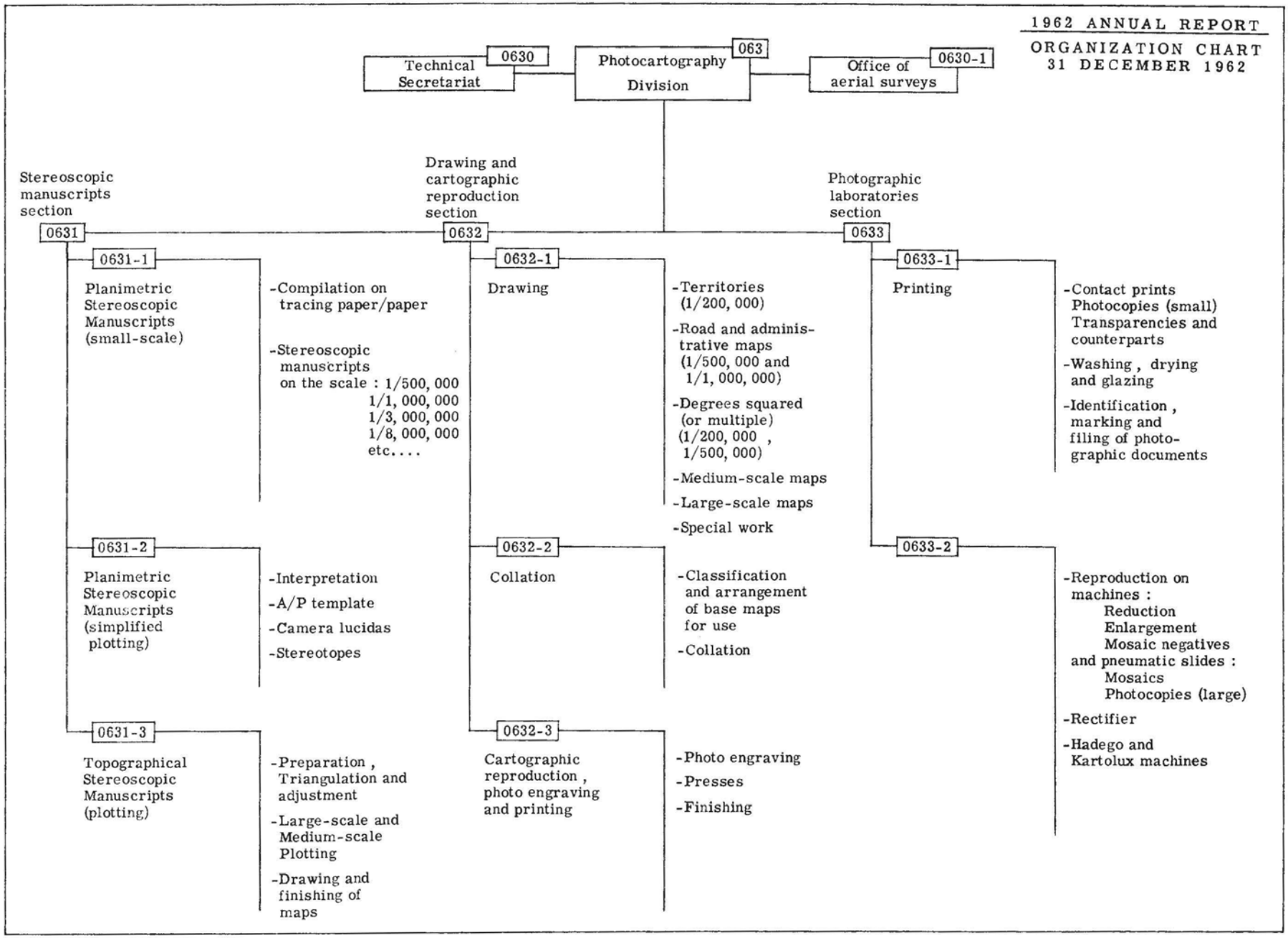
Republic of the Congo: cartography: topographical cartography



Republic of the Congo : cartography: systematic 1:50,000 mosaics



Republic of the Congo: photographic coverage



Republic of the Congo: organization chart

ANNEX V

Work of collating and arranging base maps

The work of this office consists of:

1. *Base documents*

(A) *Photo libary*: distribution and filing of aerial photographs.

(B) *Base documents for cartography*: indexing and filing:

Of base documents

Volume I: documents serving as a base for cartographic master-copies at present established by the IGC, together with the index of these master-copies.

Volume II: cartographic documents of countries bordering on the Congo, of other African countries and of other continents.

Volume III: non-cartographic documents printed by the IGC.

Of records: indexing and filing in progress.

(C) *Transfer of control marks and levelling marks*:

1. Maintenance of lists and reference plates by degree squared relating to these marks.

2. Transfer on to photos of control marks, astronomic points, frontier boundary stones and filing of these photos by degree squared.

3. Transfer on to photos of levelling marks and filing of these photos by levelling line.

4. Filing of reference cards relating to these marks.

(D) *Filing of non-transferable cartographic documents printed by the IGC*

2. *Collating of cartographic documents*

This covers the collation of the draughtsmen's work relating to cartographic documents intended for publication, including:

The reduced collation for 5 territory maps on the scale 1:200,000;
The partial collation for 11 territory maps brought up to date;
The partial collation for 2 maps on the scale 1:100,000;
The complete collation for 7 maps by degree squared, on the scale 1:200,000;
The complete collation of 20 topographic maps on the scale 1:25,000 selected for 7 colours;
The complete collation of the films of 4 topographic maps on the scale 1:50,000 selected for 7 colours;
The collation of 12 planimetric maps on the scale 1:50,000 selected for 6 colours;
The collation of a film for 1 planimetric map on the scale 1:100,000 selected for 6 colours;
The collation of 6 planimetric plates on the scale 1:50,000 selected for 4 colours (R.U.—RS 62 and 68);
The collation of two mosaics of planimetric plates on the scale 1:50,000 (R.U.—RS 62 and 68);
The collation of films for 2 planimetric plates on the scale 1:100,000 selected for 6 colours;
The collation of films for 2 planimetric plates on the scale 1:100,000 selected for 4 colours (R.U.—RS 62 and 68);
The collation of graticules for 8 territorial maps, 3 road maps by Province, 1 map on the scale 1:3,000,000, 11 maps by degree squared, 2 maps on the scale 1:100,000 and 1 planimetric plate on the scale 1:50,000;
The collation of a mosaic of planimetric plates on the scale 1:50,000 to be reduced to 1:100,000 (6 colours);
The collation of 4 mosaics on the scale 1:25,000 to be reduced to 1:50,000 topographic (7 colours);
The collation of a legend of signs and symbols for 1 map on the scale 1:100,000 (R.U.—RS 62 and 68).

ANNEX VI

Printing office

Documents				
Nature	*Number*	*Scale*	*Requested by*	*Quantity*
(A) (1) *Maps in one colour*				
Territorial organization	3	1:8,000,000	State	3,250
Regional map of Elisabethville	3	1:50,000	UN	775
Map of the Congo—printing of railway	1	1:3,000,000	State	105
Guide to Leopoldville	1	—	UN	10,000
Territory of the Congo	1	1:200,000	State	200
1/16th degree squared—maps attached for catalogue	1	1:50,000	State	5,000
				19,330
(A) (2) *Formularies in one colour*				
Miscellaneous formularies	—	—	State	54,500
				54,500
(A) (3) *Pamphlets in one colour*				
Annual Report 1961	1	—	State	400
				400
(B) *Maps in two colours*				
Territorial organization	1	1:3,000,000	State	250
Territorial organization	1	1:8,000,000	State	250
				500
(C) *Maps in three colours*				
Territories of the Congo	10	1:200,000	State	3,800
Degrees squared	10	1:200,000	State	3,800
				7,600

ANNEX VI *(continued)*

Documents					
Nature	*Number*	*Scale*	*Requested by*	*Quantity*
(D) *Maps in four colours*				
Road maps	4	1:1,000,000	State	2,140
Road maps	1	1:500,000	State	500
Shell road map	1	1:3,000,000	Shell	500
Map of Leopoldville	2	1:20,000	State	1,700
				4,840
(E) *Maps in five colours*				
Adm. and pol. road maps	3	1:1,000,000	State	950
Annexes to Annual Report plus IGC catalogue	8	1:8,000,000	State	27,500
				28,450
(F) *Maps in six colours*				
1/4-degree squared	3	1:100,000	State	1,500
				1,500
(G) *Maps in seven colours*				
1/16-degree squared	2	1:50,000	State	1,000
				1,000
(H) *Maps in eight colours*				
Map of the Ten-Year Plan	1	1:3,000,000	State	250
				250
(I) *Maps in ten colours*				
Economic map of the Congo	1	1:3,000,000	State	500
				500
(J) *Photo engraving*				
Copy on astralon including intermediate stage with a view to printing	—	—	—	1,112
Number of cycles	—	—	—	894
Copies on zinc	—	—	—	276
Plastification	—	—	—	60 m²
Graining	—	—	—	445 zincs

REPORT ON CARTOGRAPHIC ACTIVITY IN ETHIOPIA[1]

Report by the Imperial Ethiopian Mapping & Geography Institute

General

Maps of Ethiopia or parts thereof with a desirable standard of accuracy and incorporating a sufficient amount of information are a rarity to this day. Most maps that are being widely used at present are small scale inaccurate maps prepared by foreign firms from second hand information.

In this age of planned development programmes the need for accurate maps and related survey data was very greatly felt by the Imperial Ethiopian Government. As a result, various government ministries and agencies began setting up their own cartographic units to satisfy their need for maps. It was found out recently that there were over twenty such cartographic units of different sizes operating under various ministries and government agencies. Understanding that this would entail a tremendous waste in the form of duplication of services, equipment and personnel, the Imperial Ethiopian Government has now decided that all official surveys and mapping of the Empire should be carried out by a single government agency. To this effect, steps have already been taken so that all existing cartographic units will be brought together to form a single service institution—the Imperial Ethiopian Mapping and Geography Institute—to operate as a semi-autonomous department under the Ministry of

[1] The original text of this paper, submitted by Ethiopia, appeared as document E/CN.14/CART/44.

the Interior of the Imperial Ethiopian Government. This office has been designated to be the sole government agency responsible for carrying out official mapping and related surveys of the Empire and for setting up required standards for the same. Suitable headquarters to accommodate this agency are under construction and will be ready for occupation early next year.

Accomplish to date

Geodetic survey

In the programme for the Study of the Water Resources of Ethiopia, "The Multi-purpose Blue Nile River Basin Investigation Project" was a prime factor in instigating first major surveying operation in the Empire. The project known specifically as "The Blue Nile River Basin Geodetic Control Project" was carried out under the authority of special joint-fund co-operative agreements between the Imperial Ethiopian Government and the Government of the United States of America. This project was in operation from 1957 to 1961 and completed basic horizontal and vertical control networks throughout approximately 120,000 sq. miles or 307,200 sq. km. of west central Ethiopia, the area comprising the watershed of the Blue Nile River inside Ethiopia. The surveys establishing the networks were conducted with first order methods and procedures by a combined organization of Ethiopian and US Department of Commerce, Cost and Geodetic Survey personnel. The end products of the surveys have now been published and are ready for use. (See annexes I and II for Triangulation and Level networks.)

Aerial photography

The Blue Nile River Basin area had also been covered by aerial photography at approximately 1:50,000 scale in connexion with the above project.

With the assistance of the United Nations Special Fund for the planning of a development programme in the Awash River Valley an area of about 39,000 sq. km. (15,234 sq. miles) has also been photographed at 1:40,000 scale. The photography completed at the end of 1961 was carried out by Hunting Surveys. Photo mosaics of this have been prepared and are currently being used for soil study purposes.

In addition to these there is aerial photography at approximately 1:20,000 scale available for certain parts at the Imperial Highway Authority taken for road planning purposes. (See annex III for aerial coverage.)

Mapping

Ever since its inception in March 1954, the Imperial Ethiopian Mapping and Geography Institute has compiled and produced various types of topical and special purpose maps and charts for the interim use of Imperial Ethiopian Government agencies using some of the foreign prepared maps and charts as a base until such time as the required proper survey of the country is carried out and accurate base maps are produced. With the help of the aerial photography mentioned above, assistance is being rendered to government agencies who badly need maps in the form of uncontrolled and controlled planimetric maps and photo-mosaics.

Training and equipment

One of the major obstacles in organizing a mapping institution in Ethiopia was the non-availability of personnel trained in the various phases of the work and the lack of training facilities for the same. The Institute had to conduct a series of on-the-job training courses; and send selected personnel for training in institutions abroad. The necessary equipment and instruments for this programme are being procured gradually. There are at present scattered in the various cartographic units 3 Kelsh plotters, 1 Kelsh diapositive printer, 5 Multiplex units with 2 diapositive printers, 1 SEG V enlarger-rectifier, 1 Klimsch Auto-Horika copy camera, 3 contact printers and a few of the smaller stereo-instruments. Personnel are also receiving preparatory training in negative scribing on coated plastics and related laboratory operations.

Geographic place names

Until such time as the Imperial Ethiopian Mapping and Geography Institute acquires the capability to compile and produce standard topographic base maps some major preparatory activities are under way. Besides the training of personnel and the procurement of equipment the collection and standardization of geographic place names are of major importance.

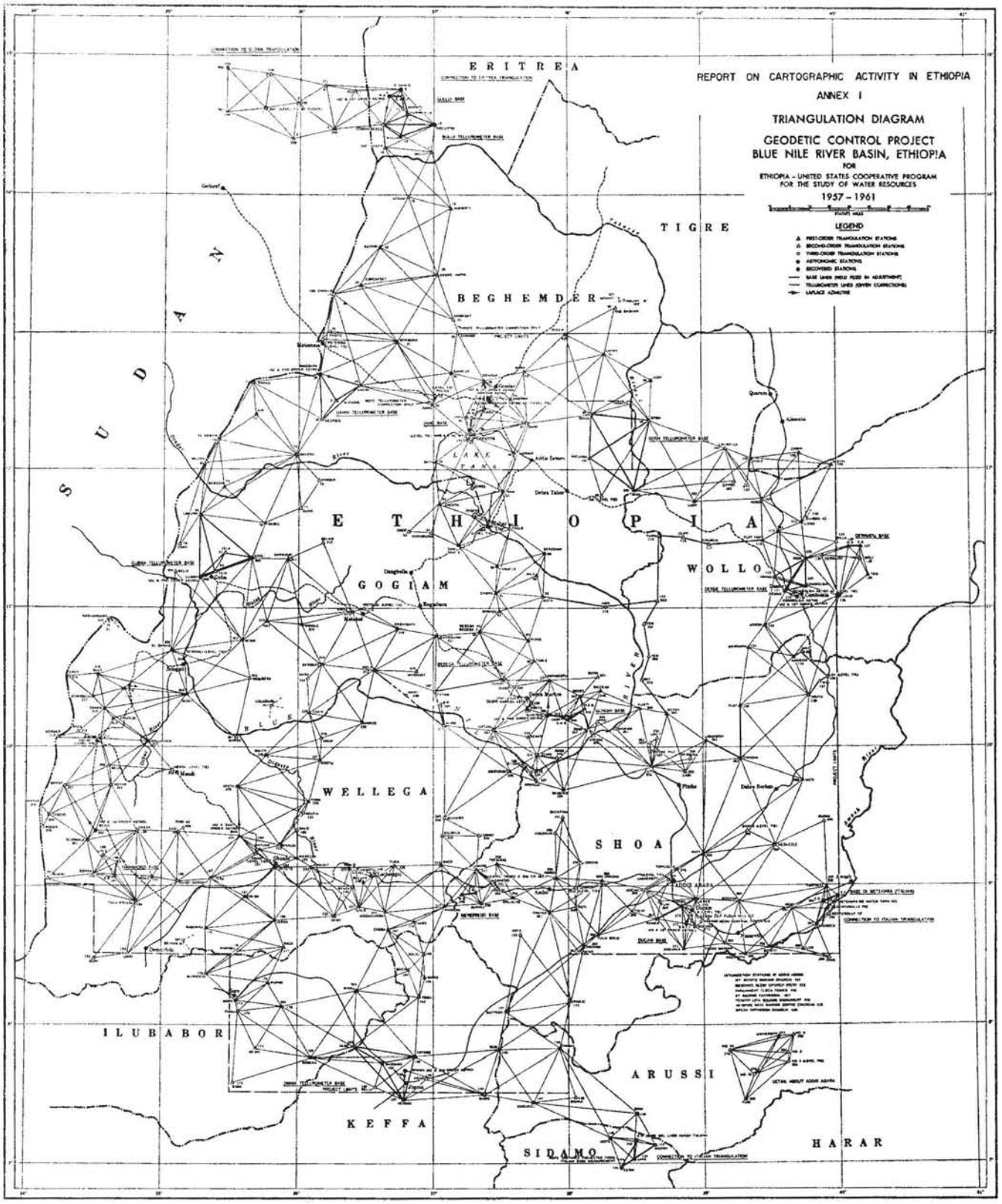
The collection of geographic place names is a major field activity at present. Place names are collected in the field by trained personnel using aerial photo-contact prints, or overlays traced off a mosaic of the same. The names are collected in "Amharic" the official language of the country. It is the intention of the Institute to produce maps not only in Amharic but also in English, which at the present is the second official language of Ethiopia. It was therefore, a prerequisite to devise a system by which one could easily and consistently transliterate names from Amharic to English.

The "Amharic to English Transliteration system" devised by the Imperial Ethiopian Mapping & Geography Institute in co-operation with selected experts from other government agencies is the result of more than six years of testing, revision and usage in the Institute. The objective of the system is to standardize the spelling of Amharic place names in English and to permit easy and accurate transliteration between the two languages. It is necesary to work toward standardization of geographic place names spelling in Ethiopia because most place names appear in three or four different spelling versions (Italian, French, British, etc.) on separate maps or often in the same publication.

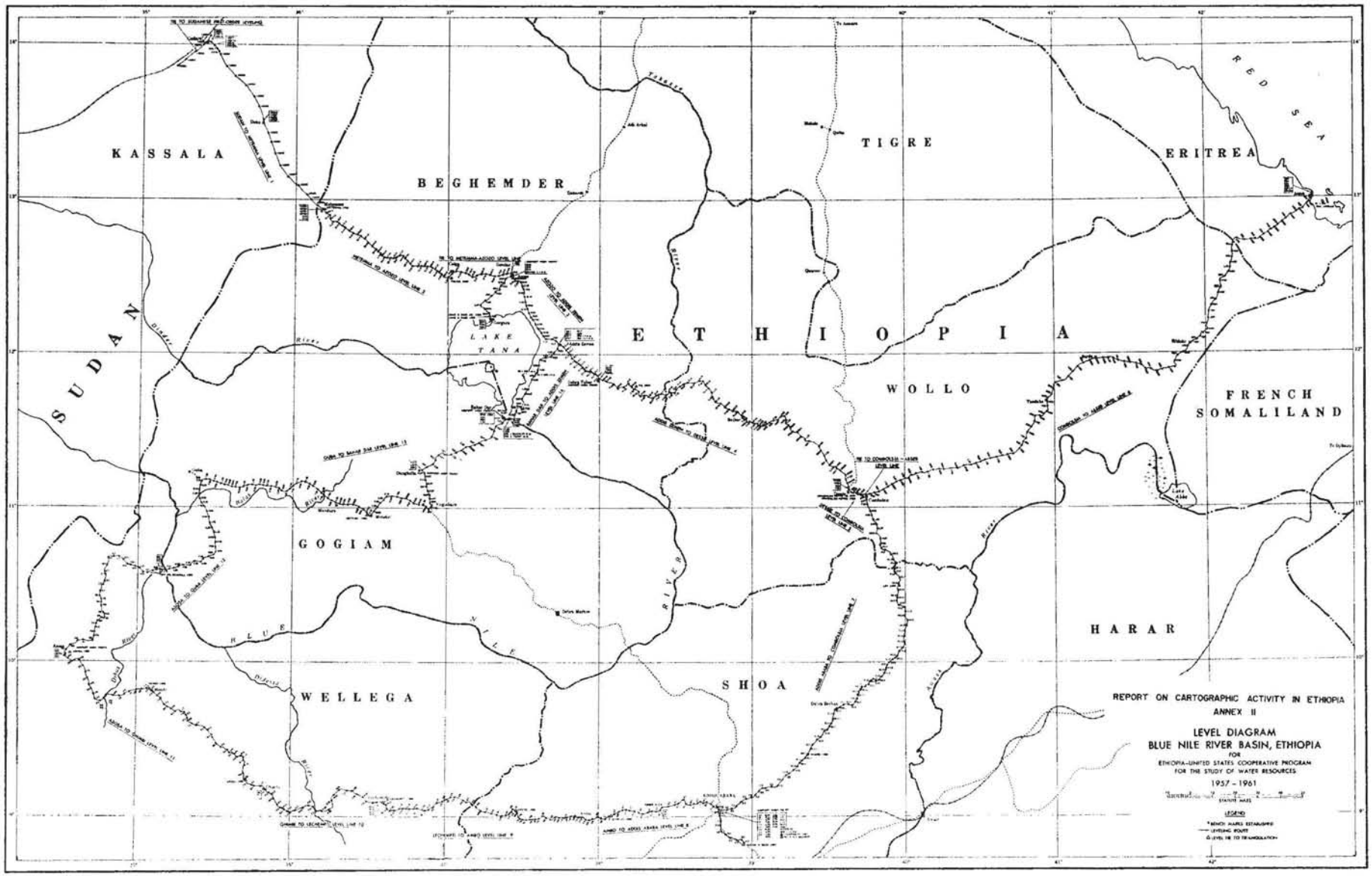
Description of system

The system is devised to transliterate from Ethiopia's official first language (Amharic) to her official second language (English), not from Amharic to any other language or a mixture of languages.

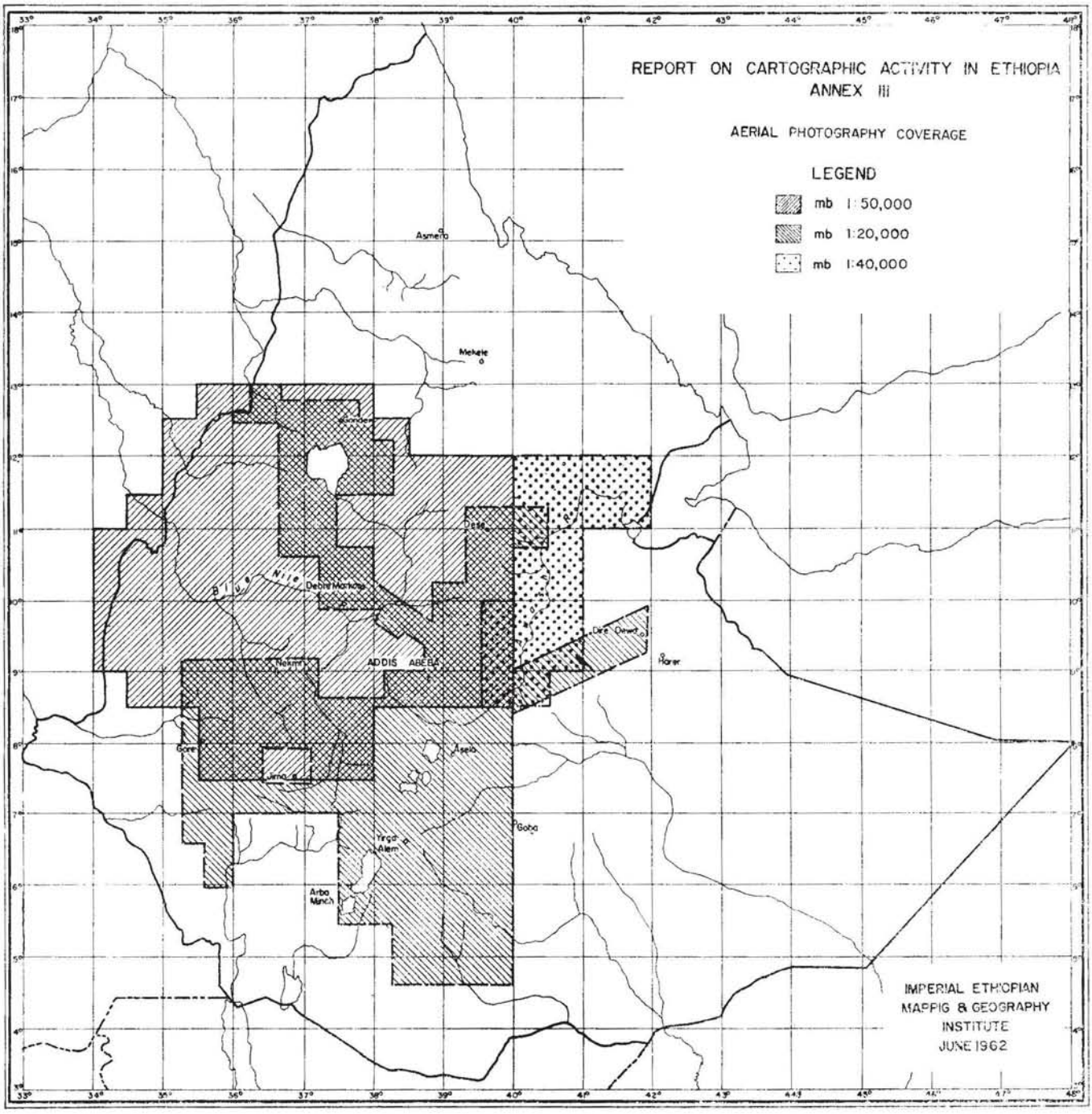
Briefly, the chart (annex IV) lists all seven (7) forms of the thirty-three (33) basic Amharic alphabet characters with their English equivalent. Each of the thirty-three (33) basic characters has seven (7) forms because there are seven vowels and each of the two hundred and thirty-one (231) phonetic characters is made by combining one of the



ANNEX I. *Ethiopia: triangulation diagram*



ANNEX II. *Ethiopia: level diagram*



ANNEX III. *Ethiopia: aerial photographic coverage*

REPORT ON CARTOGRAPHIC ACTIVITY IN ETHIOPIA
ANNEX IV

IMPERIAL ETHIOPIAN MAPPING & GEOGRAPHY INSTITUTE

Amharic To English Transliteration System

1st	2nd	3rd	4th	5th	6th	7th
ሀ Ha	ሁ Hu	ሂ Hi	ሃ Ha	ሄ He	ህ Hi	ሆ Ho
ለ Le	ሉ Lu	ሊ Li	ላ La	ሌ Le	ል Li	ሎ Lo
ሐ Ha	ሑ Hu	ሒ Hi	ሓ Ha	ሔ He	ሕ Hi	ሖ Ho
መ Me	ሙ Mu	ሚ Mi	ማ Ma	ሜ Me	ም Mi	ሞ Mo
ሠ Se	ሡ Su	ሢ Si	ሣ Sa	ሤ Se	ሥ Si	ሦ So
ረ Re	ሩ Ru	ሪ Ri	ራ Ra	ሬ Re	ር Ri	ሮ Ro
ሰ Se	ሱ Su	ሲ Si	ሳ Sa	ሴ Se	ስ Si	ሶ So
ሸ She	ሹ Shu	ሺ Shi	ሻ Sha	ሼ She	ሽ Shi	ሾ Sho
ቀ K'e	ቁ K'u	ቂ K'I	ቃ K'a	ቄ K'e	ቅ K'i	ቆ K'o
በ Be	ቡ Bu	ቢ Bi	ባ Ba	ቤ Be	ብ Bi	ቦ Bo
ተ Te	ቱ Tu	ቲ Ti	ታ Ta	ቴ Te	ት Ti	ቶ To
ቸ Che	ቹ Chu	ቺ Chi	ቻ Cha	ቼ Che	ች Chi	ቾ Cho
ኀ Ha	ኁ Hu	ኂ Hi	ኃ Ha	ኄ He	ኅ Hi	ኆ Ho
ነ Ne	ኑ Nu	ኒ Ni	ና Na	ኔ Ne	ን Ni	ኖ No
ኘ Nye	ኙ Nyu	ኚ Nyi	ኛ Nya	ኜ Nye	ኝ Nyi	ኞ Nyo
አ a	ኡ u	ኢ i	ኣ a	ኤ e	እ i	ኦ o
ከ Ke	ኩ Ku	ኪ Ki	ካ Ka	ኬ Ke	ክ Ki	ኮ Ko
ኸ He	ኹ Hu	ኺ Hi	ኻ Ha	ኼ He	ኽ Hi	ኾ Ho
ወ We	ዉ Wu	ዊ Wi	ዋ Wa	ዌ We	ው Wi	ዎ Wo
ዐ a	ዑ u	ዒ i	ዓ a	ዔ e	ዕ i	ዖ o
ዘ Ze	ዙ Zu	ዚ Zi	ዛ Za	ዜ Ze	ዝ Zi	ዞ Zo
ዠ Zhe	ዡ Zhu	ዢ Zhi	ዣ Zha	ዤ Zhe	ዥ Zhi	ዦ Zho
የ Ye	ዩ Yu	ዪ Yi	ያ Ya	ዬ Ye	ይ Yi	ዮ Yo
ደ De	ዱ Du	ዲ Di	ዳ Da	ዴ De	ድ Di	ዶ Do
ጀ Je	ጁ Ju	ጂ Ji	ጃ Ja	ጄ Je	ጅ Ji	ጆ Jo
ገ Ge	ጉ Gu	ጊ Gi	ጋ Ga	ጌ Ge	ግ Gi	ጎ Go
ጠ T'e	ጡ T'u	ጢ T'i	ጣ T'a	ጤ T'e	ጥ T'i	ጦ T'o
ጨ Ch'e	ጩ Ch'u	ጪ Ch'i	ጫ Ch'a	ጬ Ch'e	ጭ Ch'i	ጮ Ch'o
ጰ P'e	ጱ P'u	ጲ P'i	ጳ P'a	ጴ P'e	ጵ P'i	ጶ P'o
ጸ Ts'e	ጹ Ts'u	ጺ Ts'i	ጻ Ts'a	ጼ Ts'e	ጽ Ts'i	ጾ Ts'o
ፀ Ts'e	ፁ Ts'u	ፂ Ts'i	ፃ Ts'a	ፄ Ts'e	ፅ Ts'i	ፆ Ts'o
ፈ Fe	ፉ Fu	ፊ Fi	ፋ Fa	ፌ Fe	ፍ Fi	ፎ Fo
ፐ Pe	ፑ Pu	ፒ Pi	ፓ Pa	ፔ Pe	ፕ Pi	ፖ Po
Diphthongs						
ኰ Kwe		ኲ Kwi	ኳ Kwa	ኴ Kwe	ኵ Kwi	
ጐ Gwe		ጒ Gwi	ጓ Gwa	ጔ Gwe	ጕ Gwi	
ቈ K'we		ቊ K'wi	ቋ K'wa	ቌ K'we	ቍ K'wi	
ኈ Hwe		ኊ Hwi	ኋ Hwa	ኌ Hwe	ኍ Hwi	

PRONUNCIATION GUIDE

VOWELS

1st form e as in English Met
2nd form u as in English You
3rd form i as in English Marine
4th form a as in English Father
5th form e as in English May
6th form i as in English Sin
7th form o as in English Oh

CONSONANTS

G as in Good
J as in John
Ny as in Señor
Zh as in Measure

SOUNDS NOT FOUND IN ENGLISH

Letters followed by an apostrophe (') require explosive enunciation. (Example: K', T', Ch', P', Ts').

SPECIAL NOTES

* *Sounds identical to fourth form sound.*

(2) *The vowel of the 6th form (i) is eliminated in spelling except when needed in English pronunciation (Menigisiti = Mengist).*

Preliminary Edition, October 1958
First Revised Edition, April 1959
Second Revised Edition, August 1962

thirty-three consonant sounds and one of the seven vowel sounds. In addition to the two hundred and thirty-one (231) basic Amharic alphabet characters there are twenty (20) diphthongs (four basic characters with five forms each). The diphthongs are formed by combining a "w" sound with four of the thirty-three Amharic consonants in five (5) of the seven forms (excluding the second and seventh forms).

Other sound combinations have been formed in recent years, and new unofficial Amharic letters devised to represent them. These new unofficial characters have appeared in newspapers and various other publications. The new combination characters are not considered a part of the basic Amharic alphabet; thus, they do not appear on the chart or form a part of the "Amharic to English Transliteration System" devised in the Imperial Ethiopian Mapping and Geography Institute.

For the benefit of those who use this transliteration system, certain explanations are given at the bottom of the chart in the "*Pronunciation* Guide":

(*a*) Under *Vowels* each of the seven (7) sounds and an appropriate example of their pronunciation in English are listed. The first (1st) and sixth (6th) form vowel sounds do not exist, in their pure sounds, in English. The closest English sounds have been given as examples in an effort to help English speaking people in the pronunciation of Amharic place names. The first (1st) and sixth (6th) forms have a short sound and the other five (5) vowels are long. The method of underlining the two short sound vowels to distinguish them from the two similar vowel letters with long sounds was chosen mainly because it is practical to reproduce on typewriters;

(*b*) Under *Consonants* the use of the "G" and "J" is clarified and examples for "Ny" and "Zh" are given;

(*c*) Under *Sounds Not-Found in English* are the Amharic consonants which require explosive enunciation and their identification;

(*d*) The *Special Notes* are self-explanatory, and should be read carefully.

Planned operation

For the realization of a programme of aerial and ground survey an agreement was signed recently in Addis Ababa between the Imperial Ethiopian Government and the Government of the United States of America. The agreement provides for a joint survey programme of the Empire of Ethiopia.

This aerial photographic coverage and mapping programme of Ethiopia will include land, islands and water of the Empire except the area known as the "Blue Nile River Basin" which has been photographed under a previous co-operative agreement with the US Agency for International Development.

American technicians will be engaged in this project to work in close collaboration with the Imperial Ethiopian Mapping and Geography Institute.

The project entails complete aerial photography coverage, with electronically controlled horizontal and vertical positioning. Present plans call for the use of three large cargo planes because of the size of cameras and quantity of electronic equipment. Assisting will be numerous helicopters which will be used to carry supplies and equipment to remote areas.

Surveying will be done at high altitudes, somewhere about 8,000 meters or 25,000 ft. above ground. The scale of aerial photographic coverage will be 1:50,000 and 1:25,000. Both of these scales will cover the Empire of Ethiopia with the exception of the "Blue Nile River Basin Area". As many as 100 technicians will conduct geodetic control surveys and operate ground radio stations in various parts of the Empire as they work with the aerial teams.

In order to acquire general map coverage as quickly as possible and help the Imperial Ethiopian Government, the US will assist the Imperial Ethiopian Mapping and Geography Institute to become capable of producing its own topographic maps. The Institute, with the assistance of US technicians will, first of all, produce a photo map series of all Ethiopia at the scale of 1:50,000. They will also work in close collaboration to carry out a prototype topographic mapping project at a scale of 1:250,000 for areas agreed on by both Governments. In all of this, project areas with economic potentialities have been given top priority.

Details are being worked out for the training of selected Ethiopian personnel in surveying, photogrammetry and cartography both in Ethiopia and the United States. The US will also supply modern equipment required by the Imperial Ethiopian Mapping and Geography Institute for producing topographic maps.

NOTE ON FRENCH TROPICAL CARTOGRAPHY IN AFRICA[1]

By F. Joly, Senior Research Worker, Centre national de la recherche scientifique, Paris

French cartography in Africa, both in the furtherance of topographical coverage and in "geographic" or "topical" cartography, has since the end of the war been particularly noteworthy. Local additions to this rich documentation have consisted of the planning and more or less partial compilation of atlases, whether or not they come under the category of national atlases recommended by the competent committee of the International Geographic Union. Although still incomplete these experiments nevertheless open up interesting prospects for the future.

[1] The original text of this paper, submitted by France, under the title "Note sur la cartographie thématique française en Afrique", appeared in French as document E/CN.14/CART/10.

Topographical maps

I do not intend to describe here the progress of French topographical cartography in Africa, but only to point out that it is at the base of any worthwhile topical cartography. The regional geographic services of North Africa, French West Africa, French Equatorial Africa and Madagascar, and the geographic services of the young independent States, co-ordinated by the National Geographic Institute at Paris and benefiting from an ever-widening aerial coverage, have produced and are continuing to produce as quickly as possible medium-scale maps (1:50,000 and 1:1,000,000 of Algeria, Tunisia and Morocco, West Africa, Central Africa and Madagascar) and small-scale maps (1:200,000 of West and Central Africa and of the Sahara). From our point of view, however, the main work has been the preparation and publication of over-all maps from which most of the bases used for topical maps are derived (1:500,000 of North Africa and Madagascar; 1:1,000,000 over the whole African territory; 1:2,000,000 of North Africa, Madagascar, and Cameroun; general 1:500,000 of Africa).

Geographic maps

"Geographic" or "topical" cartography has been treated by numerous individual research workers, either in theses for doctorates or in various publications, and also by several private publishing houses such as Girard and Barrere, Taride or Michelin. It has made most progress, however, in the purely scientific field, as a result of the work of ministerial, university or technical services, of which the following should be mentioned in particular: local geographic services, the geological services of Algeria, Tunisia, Morocco, French West Africa and French Equatorial Africa (continued by the corresponding services of the new States), the Service of Mines of Madagascar, the Mineral Research Office of Algeria, the Moroccan Oil Company (Rabat), the Oil Research Office (Paris), the French North African Institute, the Moroccan Scientific Institute, the Institute of Saharan Research, the Scientific Research Institute of Madagascar, the Cartographic Service of the Government General of Algeria, the Documentation Division of the Présidence du Conseil (Paris), and the Office for Overseas Scientific and Technical Research (ORSTOM). Judging by the publications of these official organizations, it appears that cartographic study of the natural environment has, on the whole, advanced further and above all been on a larger scale than study of the human environment.

A. *Cartographic study of the natural environment*

Most African countries are at least partially covered by medium and small scale geological maps which will be published under a work plan which is being put into practice. There are 1:50,000 maps on Algeria and Tunisia, 1:1,000,000 maps in Morocco and Madagascar, 1:200,000 maps all over North Africa, the Sahara, in West and Central Africa and in Madagascar. An over-all 1:500,000 geological map covers the whole of North Africa and a part of the Sahara, West and Central Africa and Madagascar. Special sheets at 1:200,000 relate to North Africa, the northern Sahara, the Ivory Coast and Cameroun. Finally, French geologists have taken an active part in preparing the international 1:5,000,000 geological map of Africa.

On the basis of, or completing, these maps, isolated and more specialized experiments have concentrated on tectonic maps (at 1:2,500,000 in Madagascar), geotechnical maps (at 1:200,000 in Morocco), hydrogeological maps (at 1:50,000 and 1:200,000 in Tunisia and Morocco, at 1:500,000 in Madagascar), pedological maps (at all scales, from 1:50,000 to 1:500,000 in North Africa, Cameroun and Madagascar), geomorphological maps (at 1:100,000 in Senegal, by J. Tricart; at 1:100,000 in Morocco, by F. Joly, and in Madagascar, by H. Besairie and Ch. Robequain).

The whole of North Africa is covered by a rainfall map at 1:500,000 prepared under the supervision of H. Gaussen. H. Gaussen was also responsible for the 1:200,000 reconnaissance maps of the vegetation in North and West Africa.

B. *Cartographic study of the human environment*

The Documentation Division, the Centre for Higher Studies of Muslim Administration, ORSTOM, and the French Institute for Black Africa have published several ethnographical maps, particularly on West Africa at 1:1,000,000 and 1:5,000,000; on Central Africa and Madagascar at 1:1,000,000; on Cameroun at 1:2,000,000. There is also a 1:5,000,000 map of housing in West and Central Africa and a map of the sahara of the nomads.

Heretofore the only maps on population study have been at 1:1,000,000 prepared for Algeria and Tunisia under the supervision of J. Bertin in the cartography laboratory of the practical School for Higher Studies. A map on the same scale is being prepared for Morocco.

Large scale soil utilization maps have been published on various regions of Madagascar. F. Joly has prepared a 1:1,000,000 map on the same subject of the northern half of Morocco.

The Documentation Division has covered agriculture, at 1:5,000,000 for West and Central Africa, at 1:2,000,000 for Cameroun and at 1:10,000,000 for Africa as a whole. F. Bonnet-Dupeyron has made more detailed cartographic studies of animal breeding in Senegal and Mauritania. There is also a 1:2,000,000 map of industries and mines in Cameroun and Togo, a 1:10,000,000 general map of industries and transport in Africa, and very many local maps of communication systems.

The Documentation Division has also published a 1:2,000,000 map of the development of Central Africa and economic maps at 1:1,500,000 (Algeria, Tunisia, Morocco), 1:2,000,000 (Madagascar, Cameroun), 1:2,500,000 (Gabon), and 1:5,000,000 (West Africa).

General atlases

There is no French atlas devoted solely to Africa; but this continent naturally occupies a very large place in the *Atlas of French Colonies* published in Paris in 1934 by the Société d'éditeurs géographiques, maritimes et coloniales (Society of Geographical, Maritime and Colonial Publications) under the supervision of G. Grandidier. The atlas is in one volume, in-folio, of 146 pages, with text and

diagrams, and 39 map plates in colour. In it North Africa has been covered at 1:1,000,000 by E. F. Gautier; Black Africa at 1:3,000,000 by H. Hubert and G. Bruel; and Madagascar at 1:1,500,000 by G. Grandidier and L. Ph. May. The maps are very clear and descriptive; topographically and toponymically they are still very useful; from the economic and human points of view they are obviously out of date.

Atlas of Algeria and Tunisia

Although already old, mention must be made of an important atlas which prepared the way for more modern productions. It is the *Atlas of Algeria and Tunisia* by A. Bornard and R. de Flotte de Roquevaire, published in Algiers before the Second World War and consisting of double plates, in-folio, with a text and coloured maps. Planned as far back as 1910, the altas appeared in sections from 1925 to 1932. The aim was to present a graphic synthesis of information acquired regarding the physical, demographic and economic phenomena of Algeria and Tunisia. The scale chosen for the main maps—1:1,500,000—is well suited to a clear presentation and to comparaison of the various phenomena studied; complementary facts are represented in some reductions and some enlargements. The descriptive text, which is both full and sound, is accompanied by numerous sketches, profiles, graphs and diagrams. The atlas is of course, out of date and even some of the physical plates are of no more than historical value.

The experiment of the *Atlas of Algeria and Tunisia* has not so far been repeated in this region. But it has been completed by a work of smaller proportions for the South, the *Atlas régional des départements sahariens* (Regional Atlas of the Saharan Departments), published in 1960 by the Inter-army General Staff in Algeria. Planned within the administrative boundaries of each circle, it includes 15 studies comprising statistical and meteorological data, and annotated maps of the physical environment, of population settlements, ways of life and communications.

Finally, I would draw attention to a somewhat special historical atlas, the *Atlas des centuriations romaines de Tunisie* (Atlas of the Roman Centuriations of Tunisia) published by the Institut géographique national in 1954. This atlas shows in 44 topographical sheets at 1:50,000 and on a general plate at 1:500,000, superimposed on the relief of Tunisia, the soil utilization plan as drawn by the Roman surveyors and as plotted from the study of aerial photographs.

Atlas of Morocco

It is in Morocco that since the war the publication of atlases has shown the greatest progress. This is evidence of the remarkable advance made in the geographical knowledge of the country, and above all, of a deliberate slanting of studies and research work towards a cartographic expression of the results.

Since 1948 the development and agricultural engineering service of the Division of Agriculture, Commerce and Forests, has published, under the title *Moroccan Monograph Atlas*, several fascicles, of varying size and layout, containing maps, diagrams and statistical tables on the physical, equipment and development conditions of the regions studied; the region of Fez, Srarhna-Zemrane, the Haouz plain, the region of Doukkala-Abda; Rharb and eastern Morocco. In 1950 the same service published a Moroccan agricultural atlas, in 45 sheets, in-folio, including 40 coloured maps, based on statistics for the period 1941-1948. Some presentation plates (relief, rain, demography) referring to the whole country, are followed by general information plates showing the distribution and size of the various agricultural enterprises in Morocco (land sown with corn, livestock, arboriculture) and plates showing climate, average areas under cultivation, animal breeding and arboriculture in each of the seven large regions into which the country was then divided.

The *Atlas of Morocco*, prepared and being published by the Geography Committee of Morocco, is a national atlas, like the *Atlas of France*, the *Atlas of Belgium*, and the like. It is composed of in-folio maps accompanied by explanatory texts in the form of illustrated brochures in-octavo of some ten or twelve pages. The main maps are on the scale of 1:1,000,000 in 4 sheets, or of 1:2,000,000 on one sheet. Small sketches or maps of various scales cover complementary phenomena. The general plan includes 11 sections (introduction, physical features of the globe and meteorology, geology, relief, human geography, economic geography and regional geography) each grouping several plates. The following have appeared: annual precipitations, at 1:2,000,000; salt waters at 1:2,000,000; forests at 1:1,000,000; diseases, 4 maps at 1:4,000,000; rural European farms at 1:1,000,000; sheep and goat breeding at 1:2,000,000; beef, pig, camel and horse breeding, 4 maps at 1:4,000,000; cattle markets at 1:2,000,000; railways at 1:2,000,000; and railway traffic, 4 maps at 1:4,000,000. The following are being prepared: a map of the population, a map of bioclimatic stages and a map of mineral deposits.

Atlas of Cameroun

The *Atlas of Cameroun* is also a national atlas. The first part of the work was published in 1960 by the Cameroun Institute of Scientific Research at Yaoundé. It includes fascicles on essential physical data and vegetation: geology at 1:1,000,000, in two sheets; climatology, in two plates (pluviometry and temperatures); orohydrography, at 1:2,000,000; pedology at 1:2,000,000; and phytogeography at 1:2,000,000. Each of these coloured maps is accompanied by an explanatory text. The second part will cover human phenomena; later maps will examine economic phenomena and regional situations.

Plans and prospects

Many other works are still at the planning stage, being studied or even in process of preparation. Among the most important, mention should be made of a general and international atlas of West Africa in the production of which geographers from the French Institute for Black Africa and the French-speaking States of West Africa will participate under the guidance of Th. Monod. An atlas of the Ivory Coast is also contemplated.

All these undertakings should be encouraged and even multipled. The production of national atlases will be particularly valuable in all these young States. They could take two forms. First, they couldbe basic atlases,

containing scientific information on scales of 1:1,000,000, 1:2,000,000 or 1:3,000,000, depending on the extent of the territories. Their preparation would necessitate original detailed studies and research work in the field and on aerial photographs. These are long-term works which can only be produced very slowly and very progressively. While awaiting these collections, however, plans could be made for the fairly rapid publication of more modest maps of a size more easily handled on a smaller scale, somewhat like school atlases but fuller, more detailed and better planned. It would be a question in a way of providing a complete cartographic description of each country from the already numerous documents available nearly everywhere, a sort of graphic presentation of knowledge acquired, showing what is already known about these regions. I personally suggested that such practical atlases should be prepared for Morocco and Tunisia.

That would, at a turning point in the history of Africa, be a singularly useful task to undertake, and one which would make a useful contribution towards proving that, parallel with the text, cartography can be an excellent and convenient means of promoting research and of setting forth, in all their complexity, data relating to the geography of regions and the development of territories.

STATISTICAL RECORD OF THE CARTOGRAPHIC WORK CARRIED OUT IN THE FRENCH-SPEAKING STATES OF BLACK AFRICA AND MADAGASCAR[1]

The progress of the cartographic work carried out up to 1 January 1963 by the Institut géographique national français is shown below with respect to the following countries:

The Federal Republic of Cameroon; the Central African Republic; the Republic of Chad; the Republic of the Congo–Brazaville; the Republic of Dahomey; the Gabon Republic; the Republic of Guinea; the Republic of the Ivory Coast; the Malagasy Republic; the Republic of Mali; the Islamic Republic of Mauritania; the Republic of the Niger; the Republic of Senegal; the Togolese Republic; the Republic of the Upper Volta.

Federal Republic of Cameroon

The Federal Republic of Cameroon has an area of 474,000 km^2, including 42,000 km^2 for Western Cameroon formerly under United Kingdom trusteeship.

Infrastructure

Aerial photographic coverage at the scale 1:50,000 has been carried out and the astronomical network determined for 400,000 km^2.

Precision levelling for 7,090 km has been carried out.

Cartography

By 1 January 1963, 39 sheets and two sheets of planimetric base at the scale 1:200,000 had been published out of the 50 relating to the territory, together with 148 sheets of the map series at the scale 1:50,000.

With regard to large-scale maps, mention may be made of town plans at the scale 1:10,000 (Garoua, Maroua, Ngaoundere, Yaounde).

In Western Cameroon the Directorate of Overseas Surveys has carried out an aerial photographic coverage on films, covering a quarter of the territory. Unfortunately, owing to unfavourable weather conditions, the coverage was not of comparable quality.

Further, geodetic nets of the 1st and 2nd order have been measured for the whole frontier zone, and some planimetric base maps compiled from aerial photographs have been published.

Work planned for 1963

The systematic aerial coverage is to be continued, and precision levelling for 600 km is to be carried out.

Three planimetric base maps at the scale 1:200,000 are to be compiled before the end of 1963.

In Eastern Cameroon the mapping at the scale 1:50,000 is being continued; the current work comprises 30 sheets; they will be published gradually during the course of 1963 and 1964.

Fair drawing of three maps at the scale 1:500,000 in the South-East part of Cameroon will be completed. Lastly town plans at the scale 1:5,000 for Douala, Caroua, Maroua and Nkongsamba are in the course of preparation.

Central African Republic

The Central African Republic has an area of 617,000 km^2.

Infrastructure

Aerial photographic coverage at a scale of approximately 1:50,000 and the astronomical network have been completed.

Precision levelling for 7,125 km has been carried out.

Cartography

By 1 January 1963, 27 sheets and 35 sheets of planimetric base at the scale 1:200,000 had been published out of the 63 relating to the territory, together with 49 sheets of the map series at the scale 1:50,000.

With regard to large-scale maps, mention may be made of the plan of Bangui at the scale 1:10,000.

Work planned for 1963

The work required for transforming the provisional maps into final (definite edition) maps will be carried out for 12 sheets at the scale 1:200,000 for the eastern region of the Central African Republic.

[1] The original of this paper, submitted by France, under the title "Relevé statistique des travaux cartographiques réalisés par l'Institut géographique national français dans les États francophones d'Afrique noire et à Madagascar", appeared in French as document E/CN.14/CART/11.

Two new sheets at the scale 1:200,000 (definite edition) and 2 sheets at the scale 1:500,000 will be published before the end of the year.

A photogrammetric plotting at the scale 1:2,000 for the town of Bangui is contemplated.

The Republic of Chad

The Republic of Chad has an area of 1,284,000 km².

Infrastructure

The aerial photographic coverage at a scale of approximately 1:50,000 and the astronomical network have been completed.

Precision levelling for 11,000 km has been carried out.

Cartography

By 1 January 1963, 57 sheets and 37 sheets of planimetric base at the scale 1:200,000 had been published out of the 127 relating to the territory, together with 11 sheets of the map series at the scale 1:50,000.

With regard to large-scale maps, mention may be made of the plans of Fort-Archambault and Fort-Lamy at the scale 1:10,000.

Work planned for 1963

Photogrammetric work on 6 sheets at the scale 1:200,000 of the Tibesti and levelling of 350 km between Zouar and the Libyan frontier.

Publication of 5 sheets and 9 topographic bases at the scale 1:200,000 and of 4 sheets at the scale 1:500,000.

Republic of the Congo–Brazzaville

The Republic of the Congo has an area of 345,000 km².

Infrastructure

Aerial photographic coverage at a scale of approximately 1:50,000 has been carried out for 330,000 km².

The astronomical network has been completed for nearly all this coverage.

Precision levelling for 3,020 km has been carried out.

Cartography

By 1 January 1963, 10 sheets and 2 sheets of planimetric base at the scale 1:200,000 had been published out of the 38 relating to the territory, together with 29 sheets of the map series at the scale 1:50,000.

With regard to large-scale maps, mention may be made of the plans of Brazzaville and Pointe-Noire at the scale 1:10,000 and the surroundings of those towns at the scale 1:20,000.

Work planned for 1963

Eight sheets of the map series for the north of the Congo, at the scale 1:200,000 and also 4 sheets of planimetric base and the map of the South Congo at the scale 1:500,000 are being prepared.

The publication of 15 sheets of the map series at the scale 1:50,000 and of the town plans at the scale 1:2,000 is also planned.

The Republic of Dahomey

The Republic of Dahomey has an area of 116,000 km².

Infrastructure

Aerial photographic coverage at a scale of approximately 1:50,000 and the astronomical network have been completed.

Precision levelling for 1,090 km has been carried out.

Cartography

By 1 January 1963, 13 sheets and 1 planimetric base at the scale 1:200,000* has been published out of the 17 relating to the territory, together with 30 sheets of the map series at the scale 1:50,000.

Work planned for 1963

Ten sheets of the map series at the scale 1:50,000 are being prepared for publication.

The Gabon Republic

The Gabon Republic has an area of 267,000 km².

Infrastructure

Aerial photographic coverage at a scale of approximately 1:50,000 has been carried out for 160,000 km² and the astronomical network determined for 90,000 km².

Precision levelling for 2,780 km has been carried out.

Cartography

By 1 January 1963, 3 sheets and one planimetric base at the scale 1:200,000* had been published out of the 32 relating to the territory, together with 14 sheets of the map series at the scale 1:50,000.

Work planned for 1963

The programme of aerial photographic coverage for the equatorial areas of the Gabon was continued until the beginning of 1963; it will be resumed in October.

The astronomical network for an area of 50,000 km² that has recently been photographed is to be undertaken this year.

The publication of one sheet of the final edition (definite edition) of the map at the scale 1:200,000 and of one sheet of the planimetric base is planned for 1963.

Moreover, 20 sheets of the map series at the scale 1:50,000 are also being prepared.

Republic of Guinea

The Republic of Guinea has an area of 246,000 km².

Infrastructure

Aerial photographic coverage at the scale of approximately 1:50,000 and the astronomical network have been completed.

Precision levelling for 3,040 km has been carried out.

* Missing in French original.

Cartography

A modern map at the 1:50,000 scale, based on aerial coverage, covers a considerable part of the territory: 69 sheets have been issued, and about a hundred other are ready for plotting.

Cartography at the 1:200,000 scale, prepared from direct surveys and geodetic chains carried out between 1910 and 1943, covers the territory completely. This cartography consists of 29 sheets of varying make-up. It would clearly be very desirable to resume the preparation of these sheets by generalization of the map on a 1:50,000 scale.

The Republic of the Ivory Coast

The Republic of the Ivory Coast has an area of 322,000 km^2

Infrastructure

Aerial photographic coverage at a scale of approximately 1:50,000 and the astronomical network have been completed.

Precision levelling for 4,735 km has been carried out.

Cartography

By 1 January 1963, 9 sheets and 18 sheets of planimetric base at the scale 1:200,000* had been published out of the 35 relating to the territory, together with 81 sheets of the map series at the scale 1:50,000.

With regard to large-scale maps, mention may be made of the plan of Abidjan and its surroundings at the scale 1:10,000.

Work planned for 1963

Two final maps (definite edition) and 4 planimetric base maps at the scale 1:200,000 are being prepared, and 50 new sheets of the map series at the scale 1:50,000 are to be published by 1965.

The Malagasy Republic

The Malagasy Republic has an area of 590,000 km^2.

Infrastructure

Aerial photographic coverage at a scale of approximately 1:50,000 has been completed.

Although the geodetic network of the island is completed work on its improvement and comprehensive adjustment is being continued.

Precision levelling for 8,300 km has been carried out.

Cartography

The territory of Madagascar is covered by 453 sheets of the map series at 1:100,000 (sheets in rectangles of 1,400 km^2).

Three hundred and twenty seven sheets have been published in final edition.

The areas not yet covered by these final edition maps are nevertheless covered by a colour edition of planimetric base map compiled from aerial photographs.

With regard to large-scale maps, mention may be made of a large number of town plans including those for Tananarive, Tamatave, Majunga.

Work planned for 1963

A large-scale programme of aerial photography is to be carried out in April.

Geodetic and levelling work in various parts of the island has been planned with a view to the improvement of the infrastructure.

The field work required to make 20 planimetric bases at the scale 1:100,000 into the final edition of the map is to be be carried out in 1963.

The preparation and publication of 20 sheets of the map series at the scale 1:1000 is under way.

The Republic of Mali

The Republic of Mali has an area of 1,204,000 km^2.

Infrastructure

Aerial photographic coverage at a scale of approximately 1:50,000 has been completed.

The astronomical network has been determined for an area of approximately 1,060,000 km^2.

Precision levelling for 9,330 km has been carried out.

Cartography

By 1 January 1963, 53 sheets and 24 sheets of topographic base at the scale 1:200,000 had been published out of the 110 relating to the territory, together with 16 sheets of the map series at the scale 1:50,000.

With regard to large-scale maps, mention may be made of the plan of Bamako at the scale 1:20,000.

Work planned for 1963

Publication of the map of Bamako at the scale 1:500,000 and of 3 planimetric bases at the scale 1:200,000.

The Islamic Republic of Mauritania

The Islamic Republic of Mauritania has an area of 1,086,000 km^2.

Infrastructure

Aerial photographic coverage at a scale of approximately 1:50,000 has been completed.

The astronomical network has been determined for an area of 725,000 km^2.

Precision levelling for 4,655 km has been carried out.

Cartography

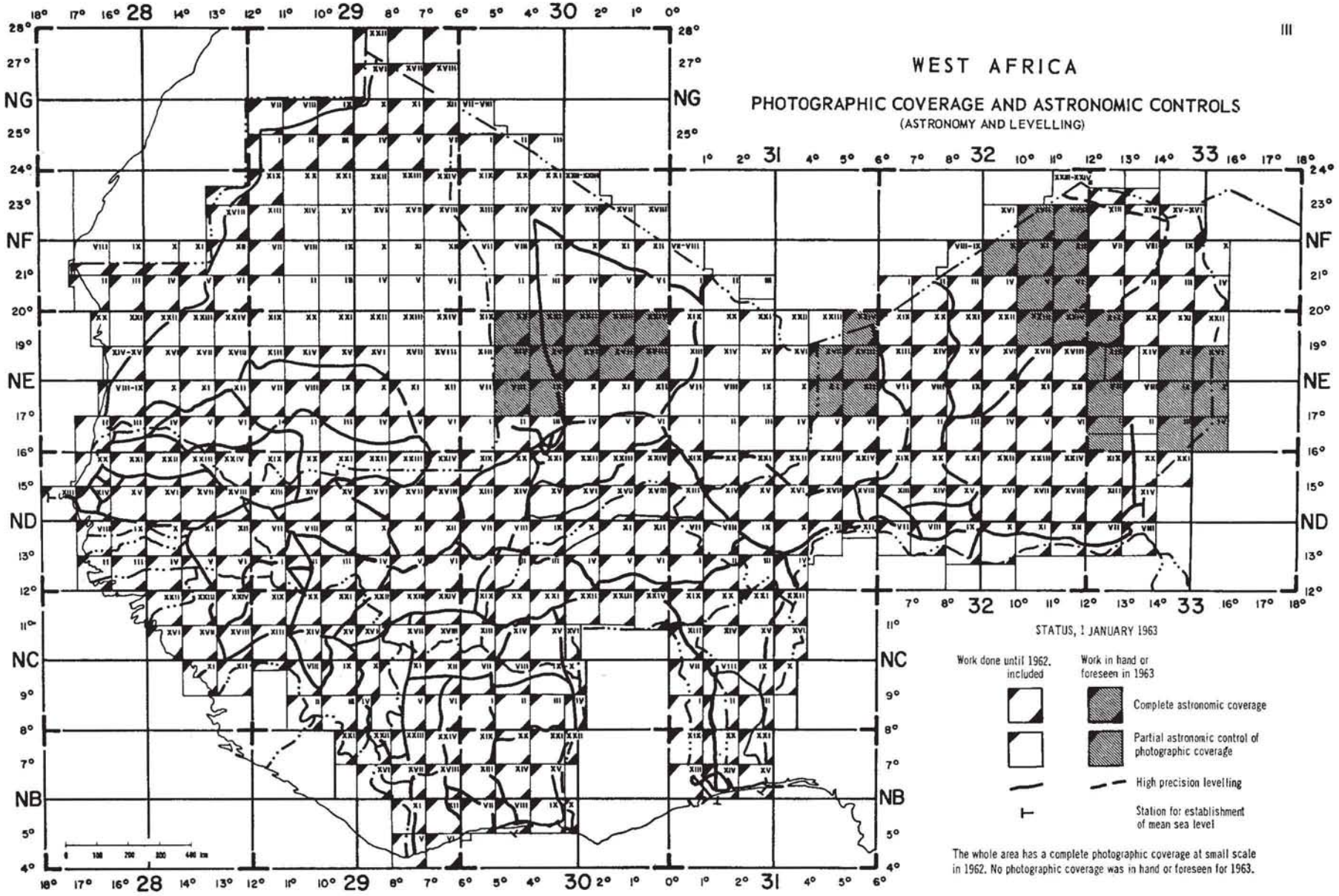
By 1 January 1963, 14 sheets and 36 planimetric or topographic bases at the scale 1:200,000 had been published out of the 105 relating to the territory.

Work planned for 1963

Precision levelling for 650 km in the South-West part of the territory.

Publication of 10 planimetric bases at the scale 1:200,000 covering the area located to the north of the 16th parallel.

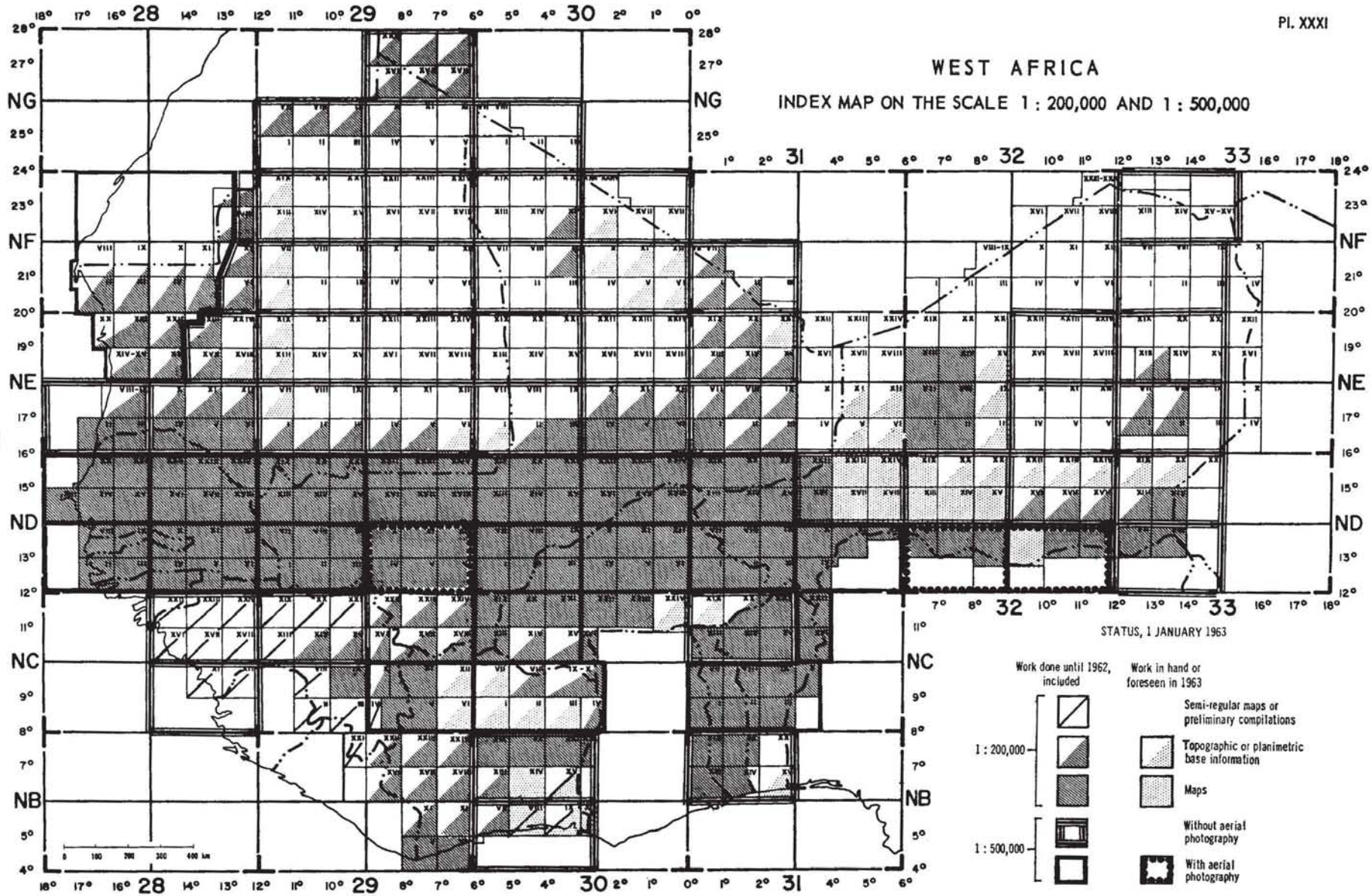
* Missing in French original.



West Africa: photographic coverage and astronomic controls

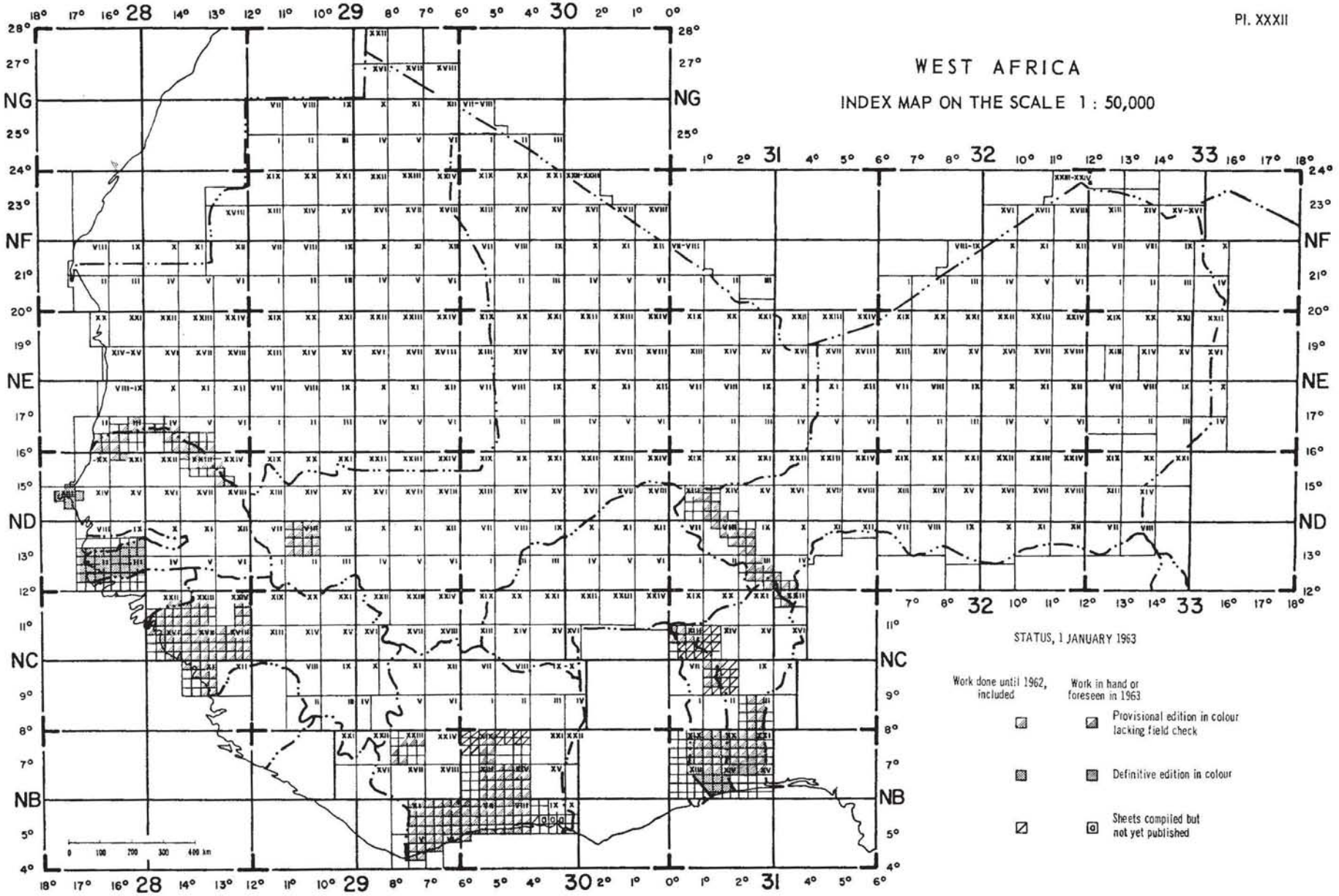
WEST AFRICA

INDEX MAP ON THE SCALE 1 : 200,000 AND 1 : 500,000

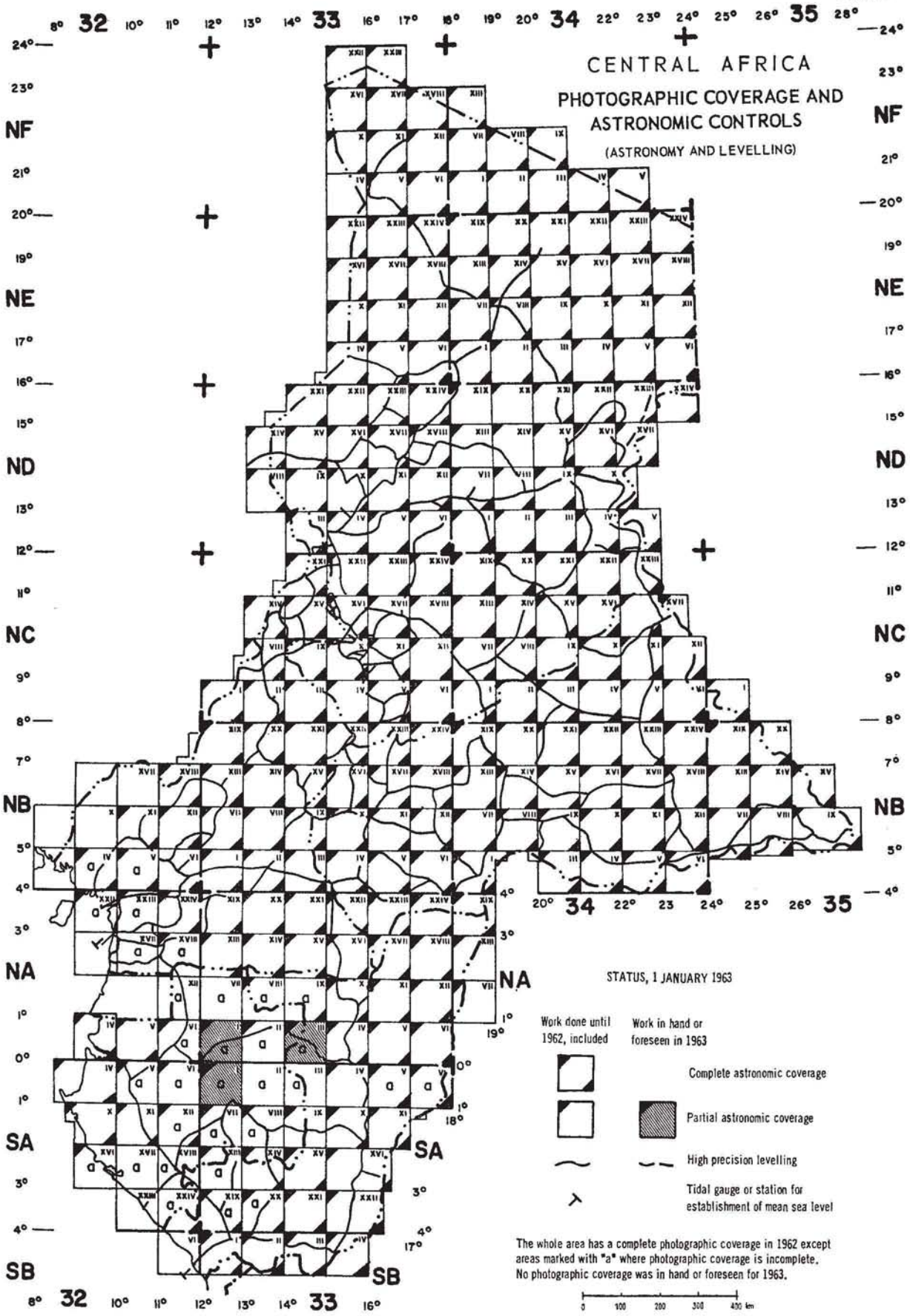


STATUS, 1 JANUARY 1963

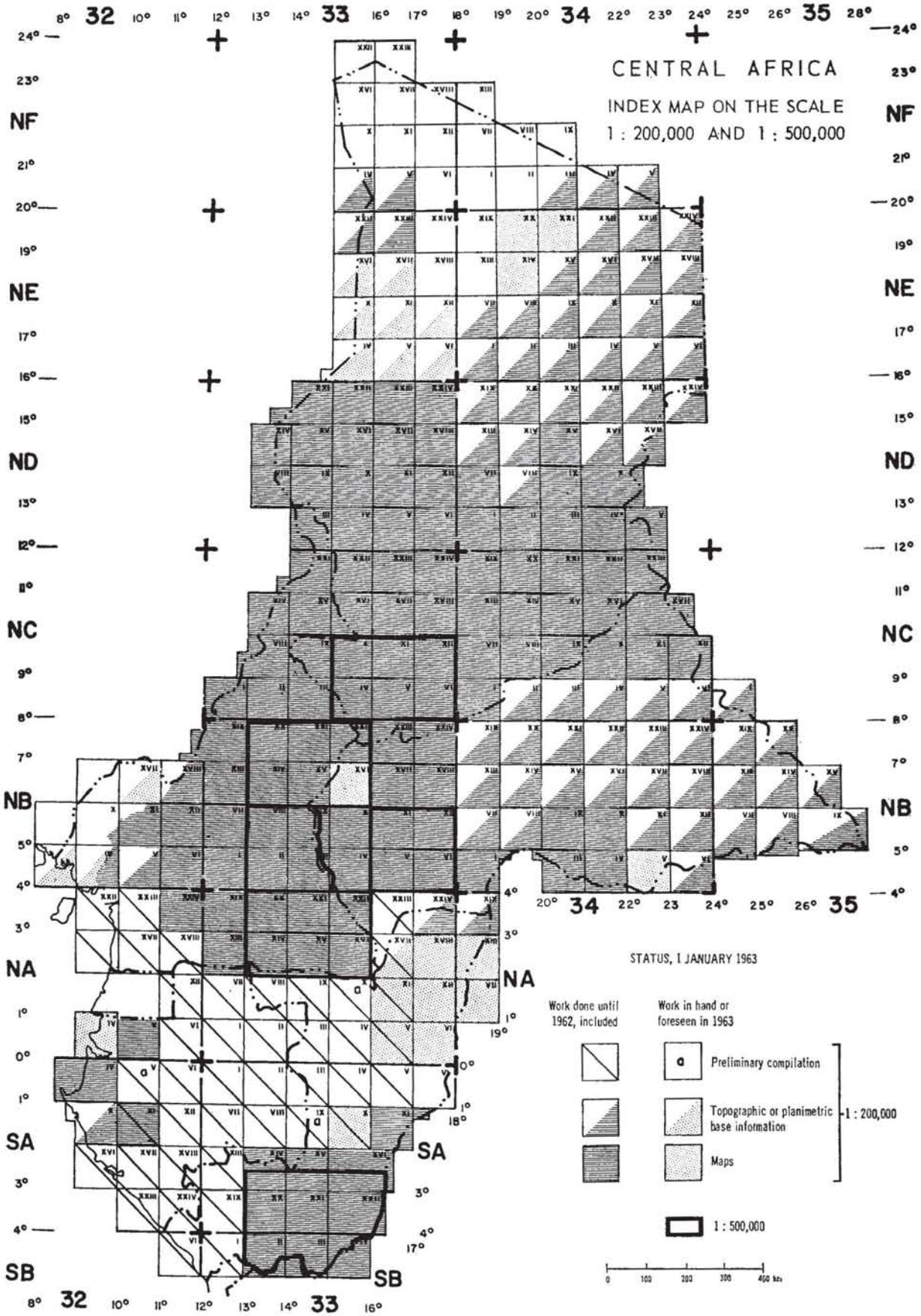
	Work done until 1962, included	Work in hand or foreseen in 1963
1 : 200,000		Semi-regular maps or preliminary compilations
		Topographic or planimetric base information
		Maps
1 : 500,000		Without aerial photography
		With aerial photography



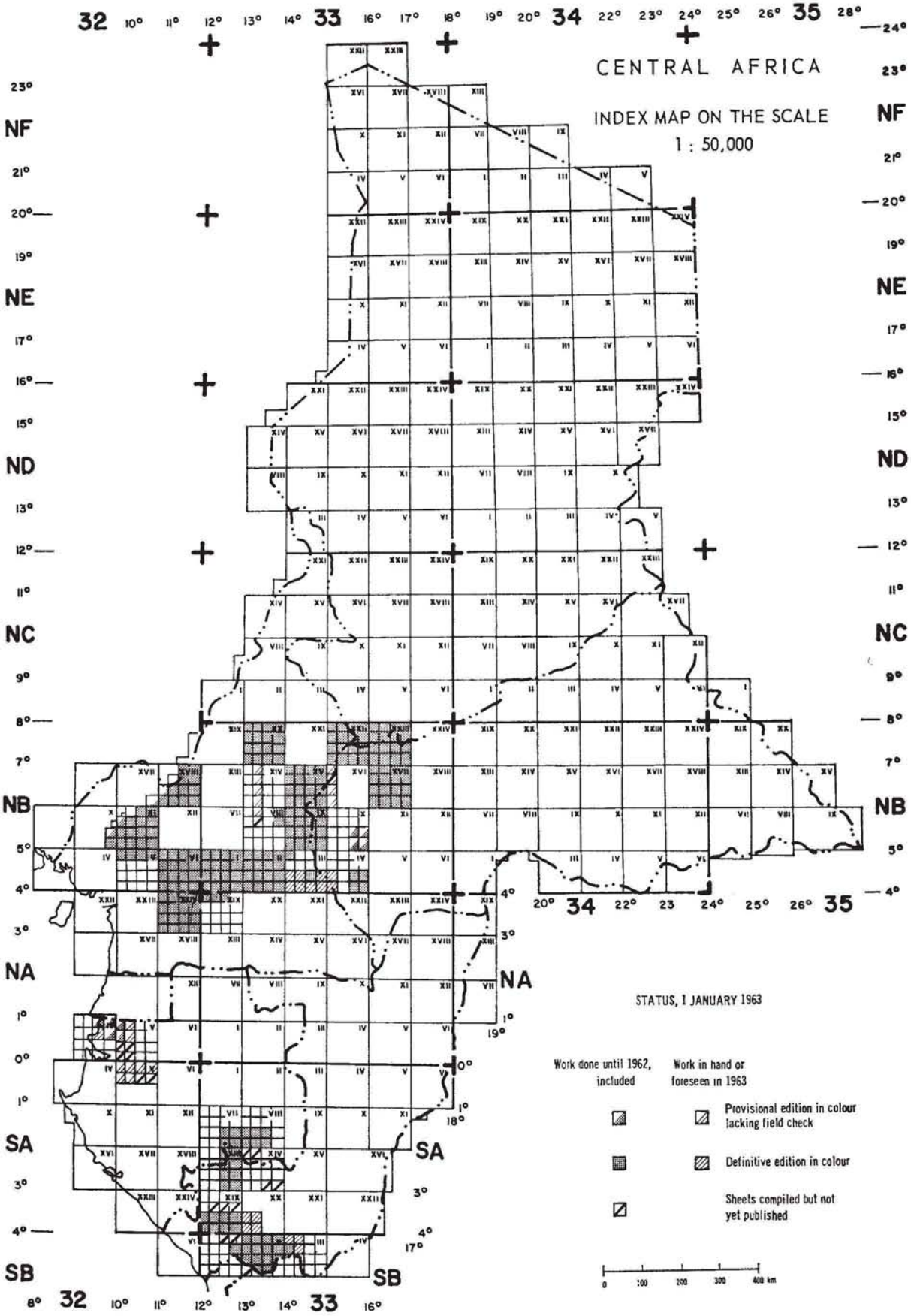
West Africa: index map on the scale 1:50,000



Central Africa: photographic coverage and astronomic controls



Central Africa: index map on the scale 1:200,000 and 1:500,000

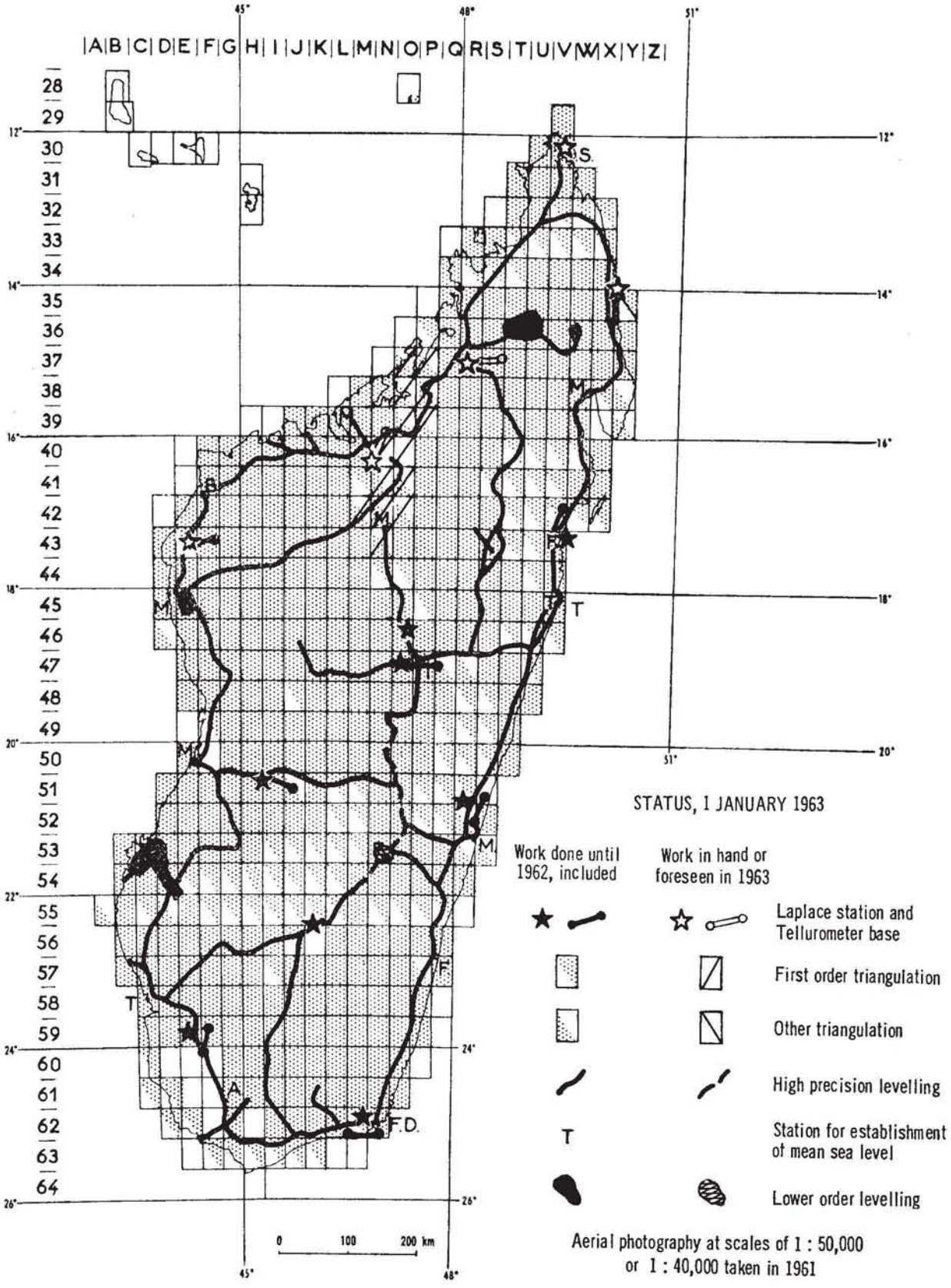


Central Africa: index map on the scale 1:50,000

MADAGASCAR

PI. XXXVIII

GEODESY AND LEVELLING

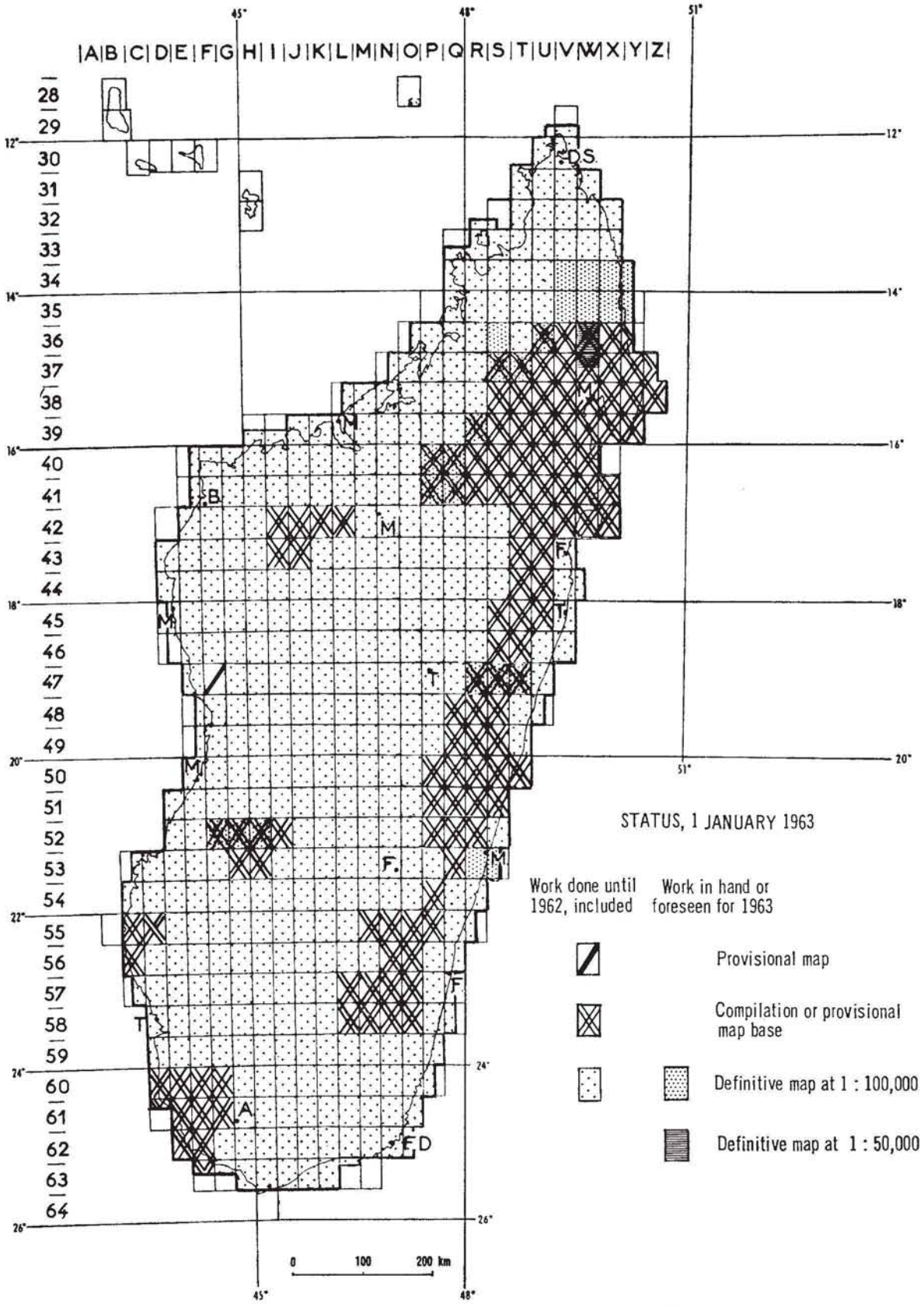


Madagascar: geodesy and levelling

MADAGASCAR

STATUS OF MAPPING AT SCALE 1 : 50,000 AND 1 : 100,000

FINAL EDITION

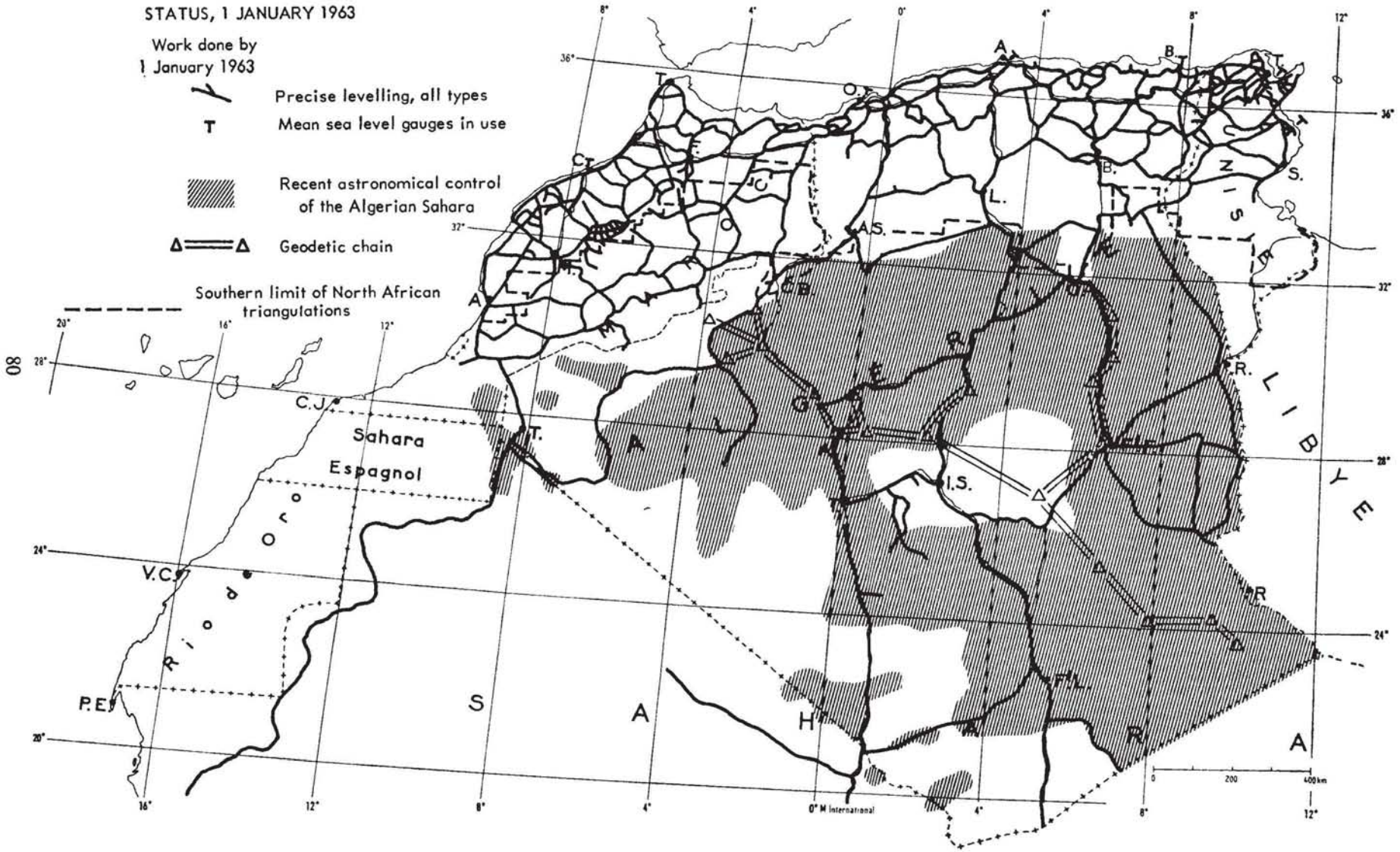


Madagascar: status of mapping at scale 1:50,000 and 1:100,000

NORTH AFRICA AND SAHARA

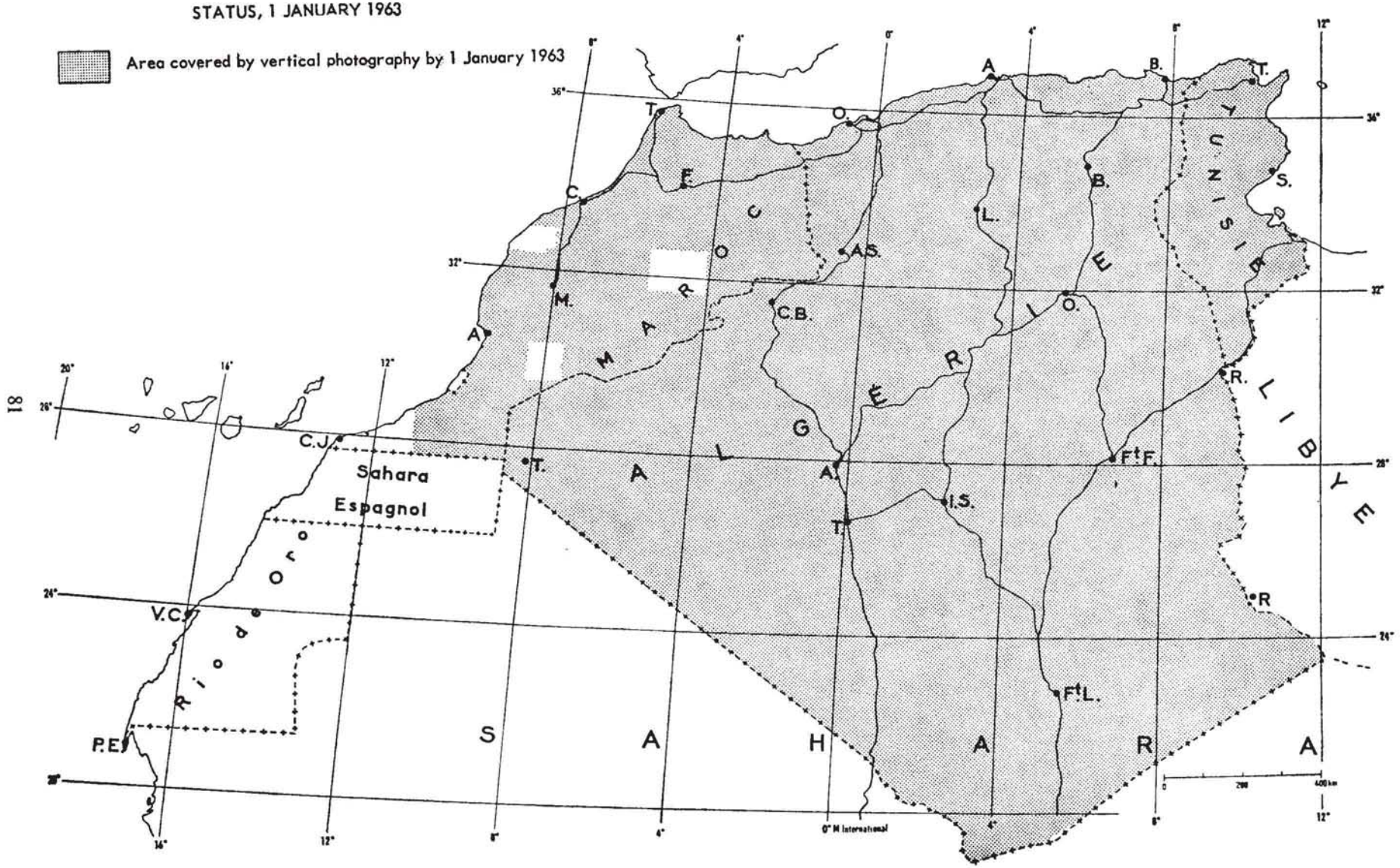
PRECISE LEVELLING — GEODESY — ASTRONOMICAL CONTROL

AND 1/200,000 SURVEYS OF THE ALGERIAN SAHARA



North Africa and Sahara: precise levelling—geodesy—astronomical control and 1:200,000 surveys of the Algerian Sahara

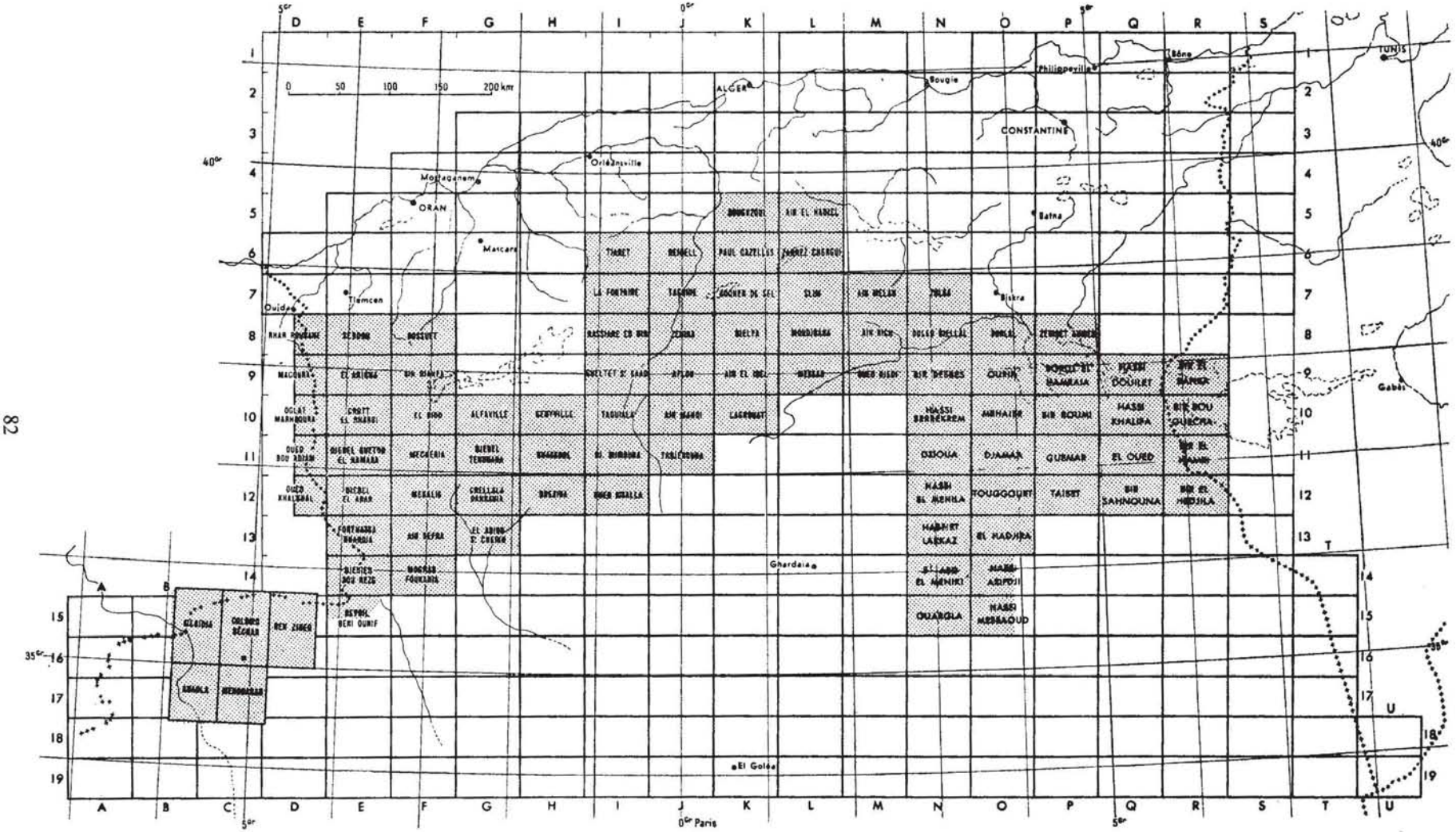
NORTH AFRICA
AIR PHOTO COVER



North Africa: air photo cover

ALGERIA AND SAHARA - 1/100,000

SHEETS PUBLISHED



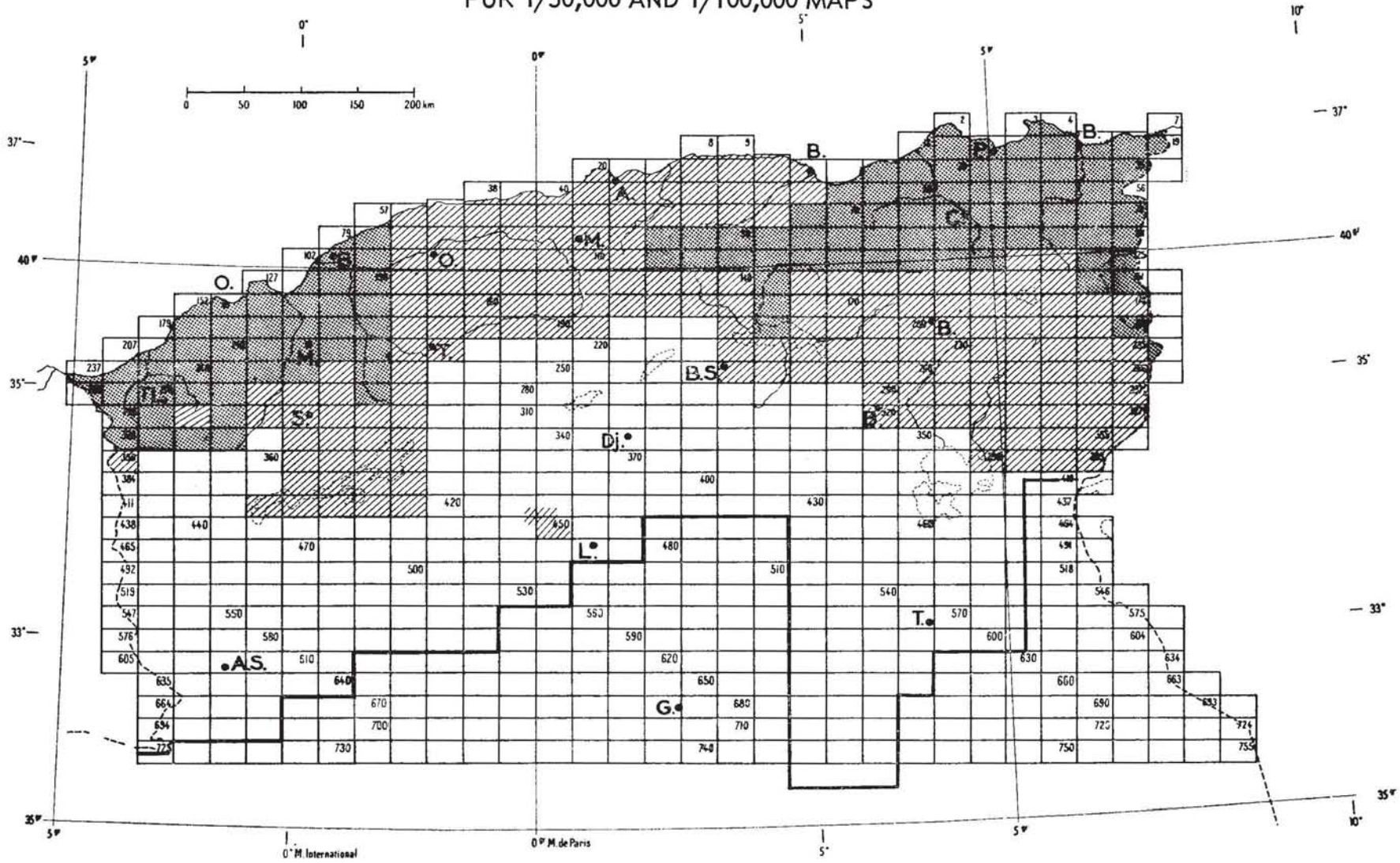
STATUS, 1 JANUARY 1963

Sheets published by 1 January 1963

Algeria and Sahara: 1:100,000—sheets published

ALGERIA AND SAHARA

TOPOGRAPHICAL AND PHOTOGRAMMETRIC SURVEYS FOR 1/50,000 AND 1/100,000 MAPS



STATUS, 1 JANUARY 1963

Regular, final surveys

Old surveys, to be repeated

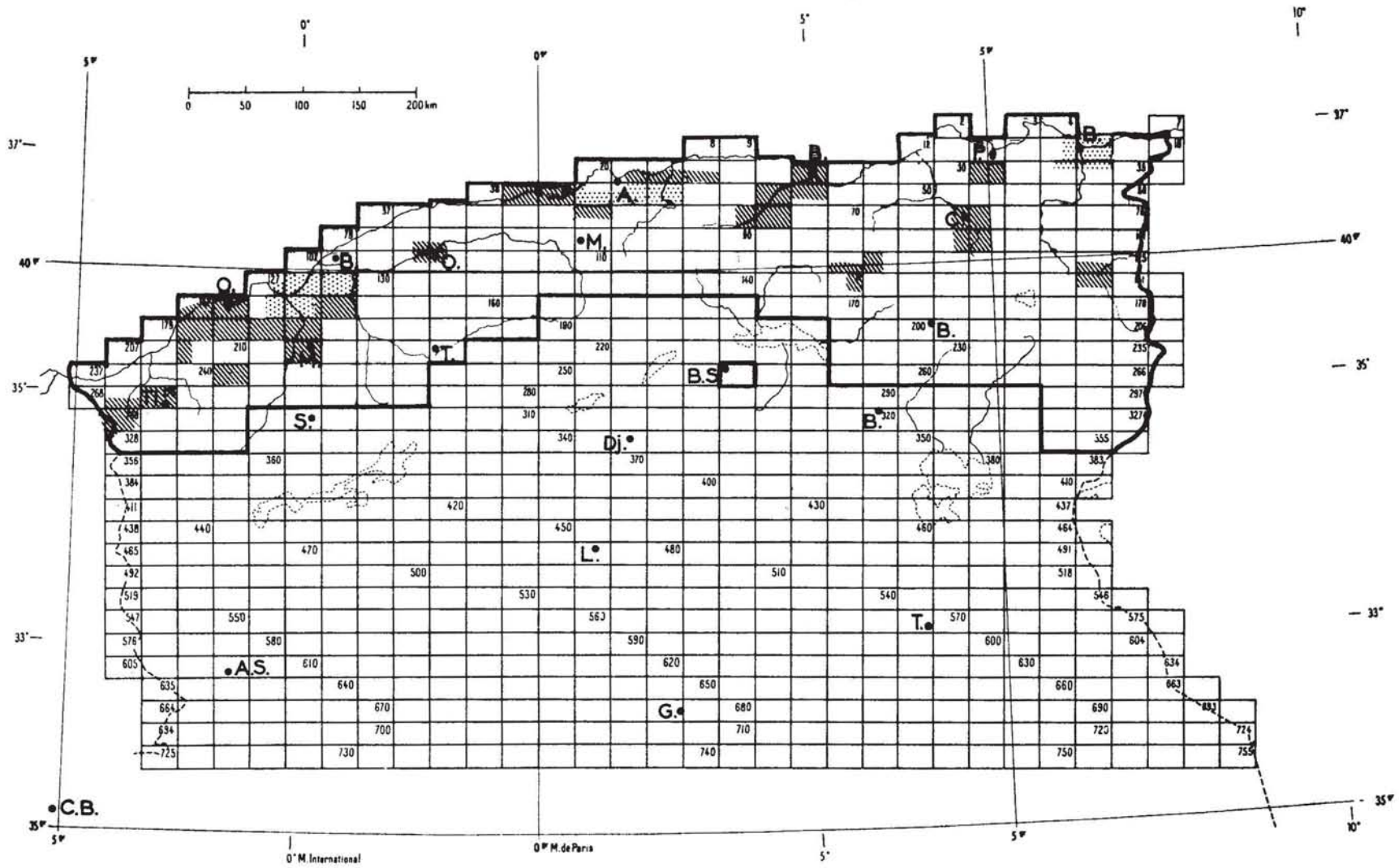
Southern limit of 1/100,000 surveys on 1 January 1963

Algeria and Sahara : topographical and photogrammetric surveys for 1:50,000 and 1:100,000 maps

ALGERIA

NEW 1/20,000 MAP

AND AIR PHOTO COVER AT 1/25,000



STATUS, 1 JANUARY 1963

Plotted at 1/20,000 — Work done by 1 January 1963 — Limit of air photo cover at 1/25,000

Algeria: new 1:20,000 map and air photo cover at 1:25,000

MOROCCO

REGULAR DETAILED TRIANGULATION

STATUS, 1 JANUARY 1963

Work done by
1 January 1963

More than one point per 40 km^2

Dense triangulation, with altitudes

Dense triangulation, without altitudes

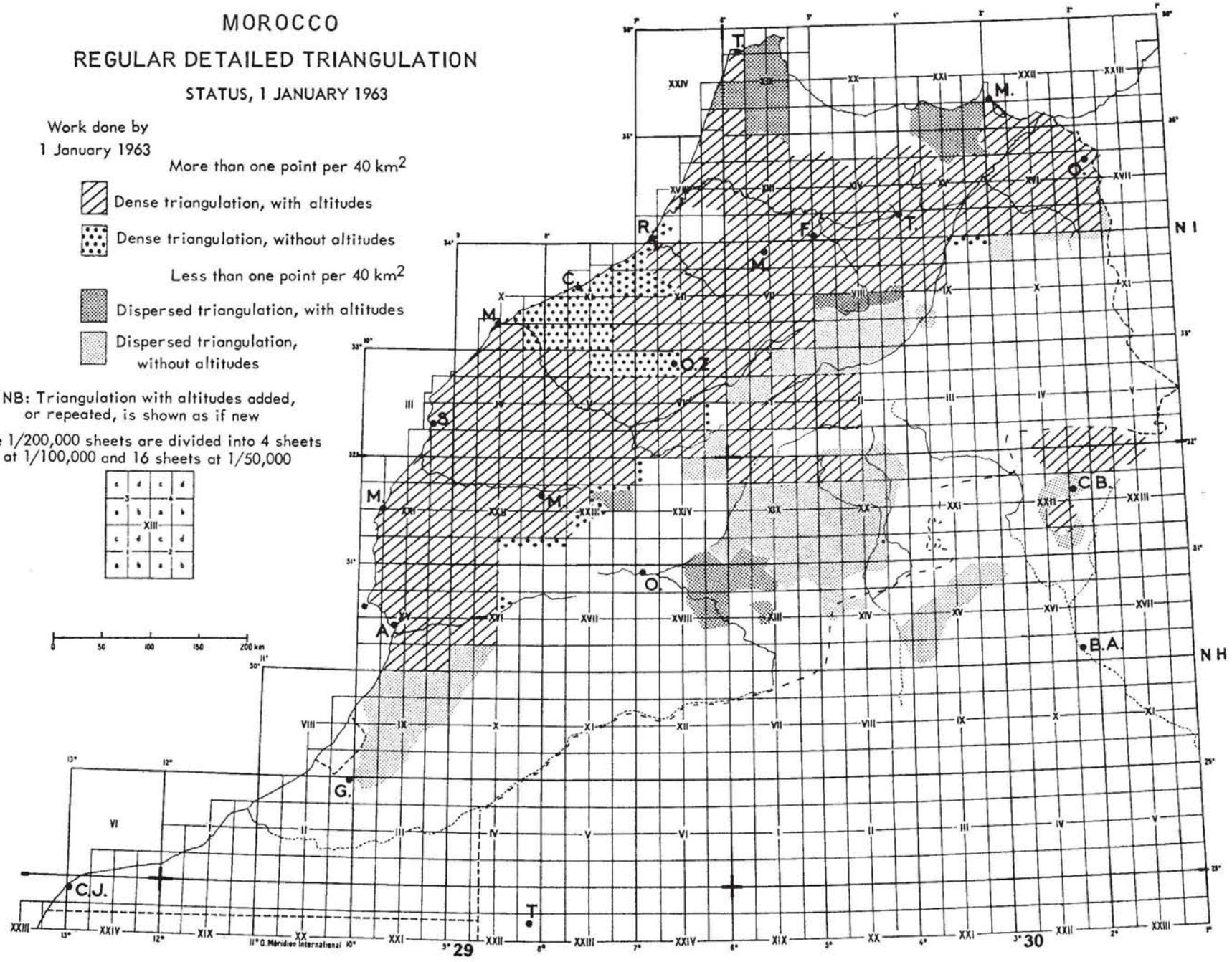
Less than one point per 40 km^2

Dispersed triangulation, with altitudes

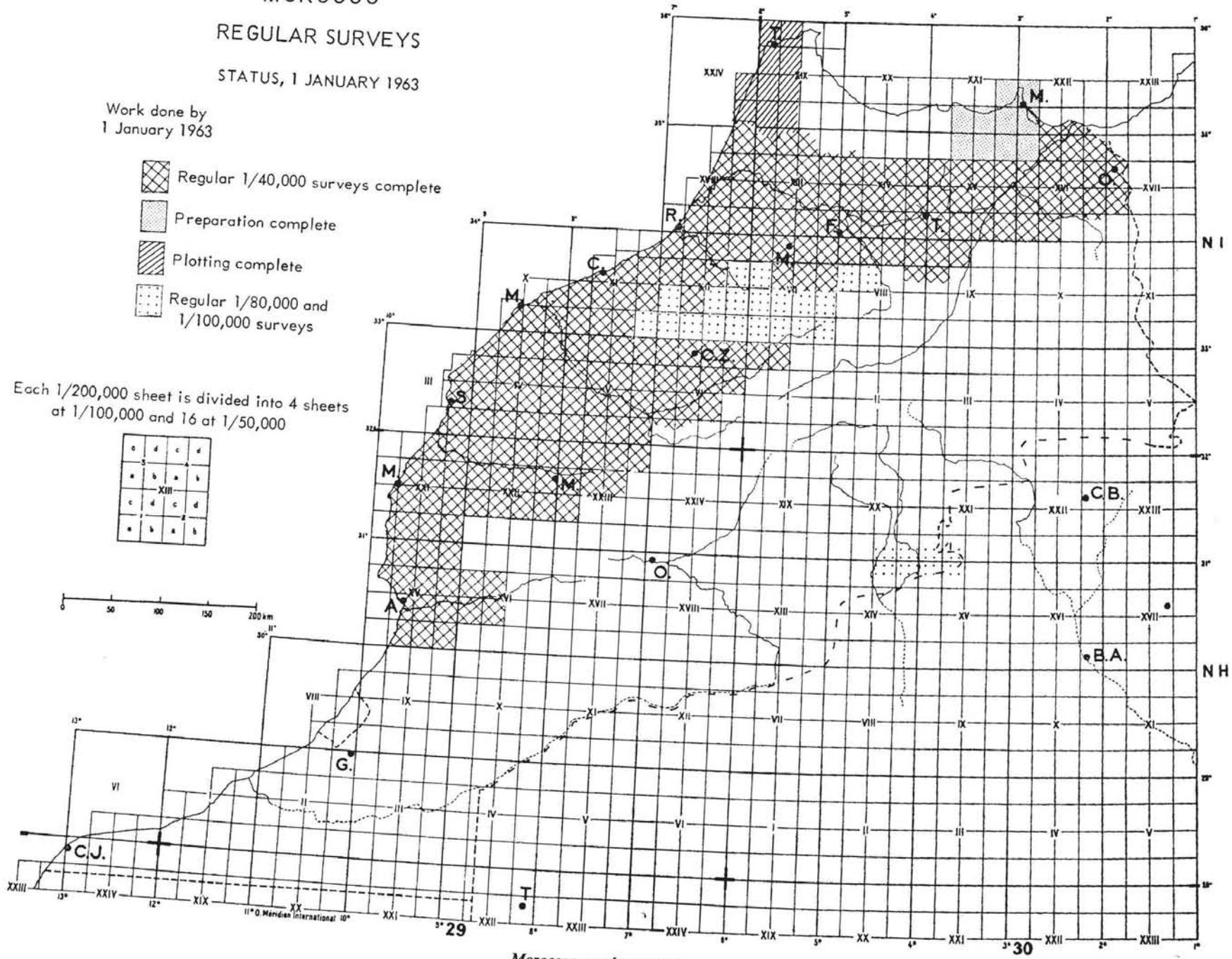
Dispersed triangulation, without altitudes

NB: Triangulation with altitudes added, or repeated, is shown as if new

The 1/200,000 sheets are divided into 4 sheets at 1/100,000 and 16 sheets at 1/50,000



Morocco : regular detailed triangulation



Morocco : regular surveys

MOROCCO

1/100,000 AND 1/200,000 RECONNAISSANCE MAPS

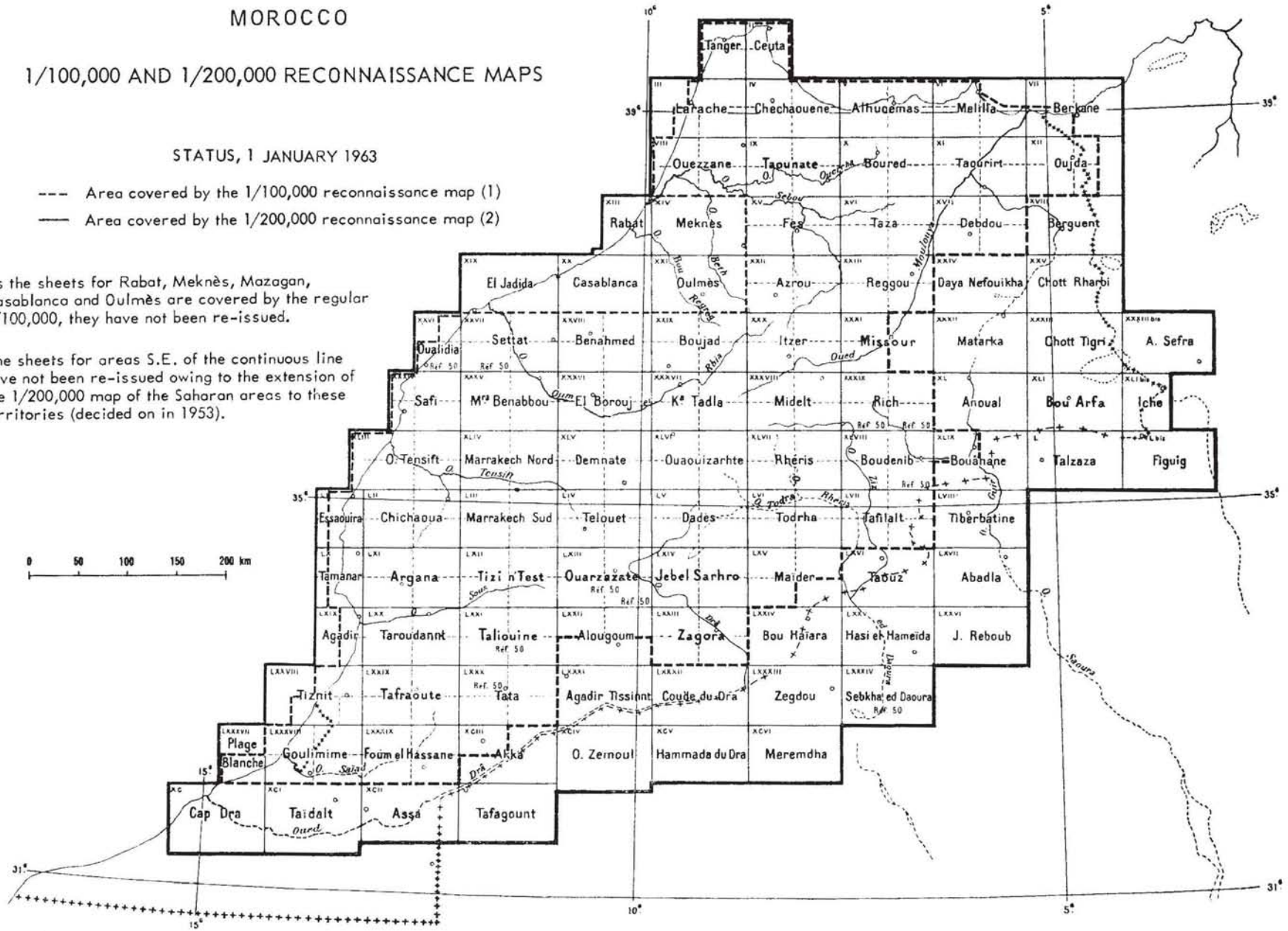
STATUS, 1 JANUARY 1963

--- Area covered by the 1/100,000 reconnaissance map (1)

—— Area covered by the 1/200,000 reconnaissance map (2)

(1) As the sheets for Rabat, Meknès, Mazagan, Casablanca and Oulmès are covered by the regular 1/100,000, they have not been re-issued.

(2) The sheets for areas S.E. of the continuous line have not been re-issued owing to the extension of the 1/200,000 map of the Saharan areas to these territories (decided on in 1953).

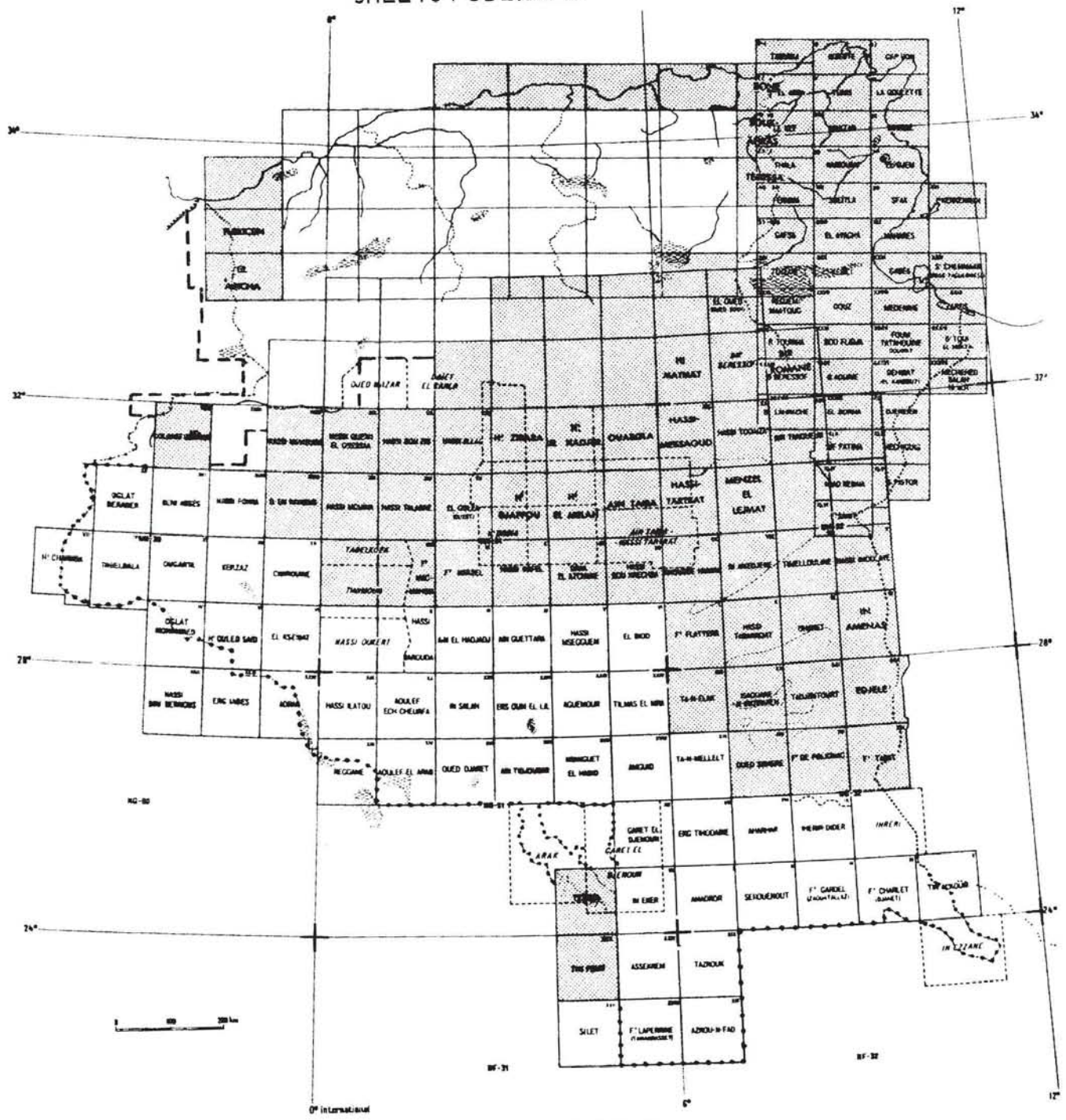


Morocco: 1:100,000 and 1:200,000 reconnaissance maps

ALGERIA SAHARA TUNISIA

1/200,000 MAPS

SHEETS PUBLISHED



STATUS, 1 JANUARY 1963

New Map: Sheet published before 1963

..... Limit of the old 1/200,000 map of the Saharan areas

——— Limit of the old 1/200,000 map of Algeria and Tunisia

Algeria—Sahara—Tunisia : 1:200,000 maps—sheets published

The Republic of the Niger

The Republic of the Niger has an area of 1,189,000 km².

Infrastructure

The aerial photographic coverage at a scale of approximately 1:50,000 has been completed and the astronomical network determined for 975,000 km².

Precision levelling for 6,300 km has been carried out.

Cartography

By 1 January 1963, 30 sheets and 8 sheets of planimetric base at the scale of 1:200,000 had been published out of the 120 relating to the territory. With regard to large-scale maps, mention may be made of the plans of Niamey, Zinder, and Maradi at the scale 1:15,000.

Work planned for 1963

Publication of 8 sheets of final edition and 12 sheets of planimetric base at the scale 1:200,000; also important mapping work at the scale 1:50,000 in the Niger valley and on the frontier with Nigeria, which will be continued in 1964 and 1965.

The Republic of Senegal

The Republic of Senegal has an area of 197,000 km².

Infrastructure

Aerial photographic coverage at a scale of approximately 1:50,000 and the astronomical network have been completed.

Precision levelling for 2,570 km has been carried out.

Cartography

The territory of Senegal is covered by 27 sheets of the map series at the scale 1:200,000. All these sheets have been published, as well as 26 sheets of the map series at the scale 1:50,000 and 33 planimetric base maps at the same scale.

With regard to large-scale maps, mention may be made of the plan of Dakar at the scale 1:7,500 and the maps of the Cape Verde peninsula at the scale 1:10,000 and 1:20,000.

Work planned for 1963

Work on the preparation of 32 sheets of the map series at the scale 1:50,000 in the east of the territory will be started in 1963 and continued during 1964 and 1965.

The Togolese Republic

The Togolese Republic has an area of 55,000 km².

Infrastructure

Aerial photographic coverage at a scale of approximately 1:50,000 and the astronomical network have been completed.

Precision levelling for 1,120 km has been carried out.

Cartography

The territory of Togo is covered by 9 sheets of the map series at the scale 1:200,000. All these sheets have been published.

Forty-one sheets of the map series at the scale 1:50,000 have also been published.

With regard to large-scale maps, mention may be made of the plan of Lome at the scale 1:15,000.

No new work is planned for 1963.

The Republic of the Upper Volta

The Republic of the Upper Volta has an area of 274,000 km².

Infrastructure

Aerial photographic coverage at a scale of approximately 1:50,000 and the astronomical network have been completed.

Precision levelling for 2,280 km has been carried out.

Cartography

By 1 January 1963, 26 sheets and 6 sheets of planimetric base at the scale 1:200,000 had been published out of the 34 relating to the territory.

Work planned for 1963

Publication of the last two sheets of planimetric base relating to the territory, and field checking of 3 planimetric bases with a view to completing them for the final edition.

MICHELIN ROAD MAPS OF AFRICA[1]

The Michelin Touring Services have long been interested in African cartography; indeed, their first road map for the African countries was produced in 1929.

Michelin publications on Africa are of two kinds:

I. *Africa in 3 sheets, scale 1:4,000,000*, which will cover the whole of the African continent.

II. *Detailed medium-scale maps, scale 1:800,000 to 1:1,000,000*, showing one country or State.

I. *Africa in 3 sheets, scale 1:4,000,000* (fig. 34)

(*A*) Sheet *No. 155* "*Afrique Centre et Sud-Madagascar*" ("Central Africa and Southern Madagascar") which extends from the Congo (Leopoldville) to the Cape and from Douala to Somalia. On this sheet, Madagascar is represented by an inset map.

In this type of map, two factors are given particular prominence on a document produced in 5 colours:

(1) Traffic: the different lines of communication ranging from the track of beaten earth to the asphalt-surfaced road are represented by a series of shades appropriate to the

[1] The original text of this paper, submitted by France, under the "Les cartes routières Michelin de l'Afrique", appeared in French as document E/CN.14/CART/14.

nature of the soil, driving conditions and seasonal climatic variations. Hydrography also figures largely on the map together with the transport facilities it offers. Distances are given in kilometres and miles.

Finally, it should be noted that the main routes across Africa are shown in exergue while picturesque stretches of road are indicated by green edging.

(2) Resources: these are examined from two aspects:

(*a*) Those that the traveller will require each day for himself and his vehicle (hotels, restaurants, mechanics, petrol filling stations, etc.).

(*b*) Those which are the direct objects of touring proper and help the traveller to plan a journey under the most favourable conditions (prominent mention of the main sightseeing attractions, representation of national parks with camping sites, climatic information, which appears inset on the map and gives details of rainfall as well as maximum and minimum mean temperatures for each month).

FIGURE 1 **Map of Africa in 3 sheets (1)** at 1/4,000,000

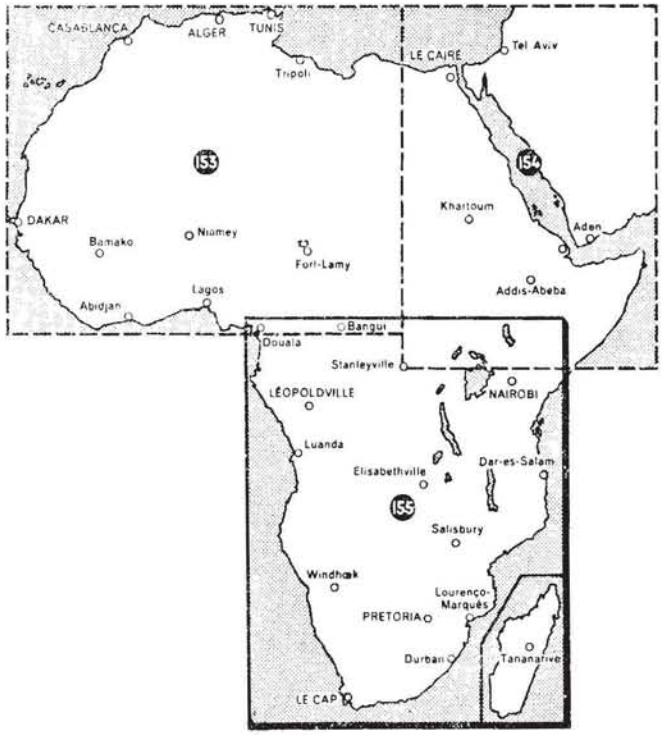


FIGURE 1. *Michelin map of Africa at 1:4,000,000*

(1) The Sahara is now covered by the map nº 152.

(*B*) The second sheet, *No. 153*, which will appear during the summer of 1964, will cover the *North and West of the continent*, from Dakar to the Sudan and from Algiers to Abidjan. Part of this region is at present represented on map *No. 152*, which must obviously be withdrawn.

(*C*) The third sheet *No. 154*, for which no publication date can yet be fixed, will cover the *North-East of Africa*.

II. *Detailed maps, on a medium-scale from 1:800,000 to 1:1,000,000* (fig. 2)

(*a*) Map *No. 172* of *Algeria and Tunisia*, scale 1:1,000,000, with enlargements of Algiers, Oran, Tlemcen and Tunis on scales of either 1:300,000 or 1:200,000, together with town plans.

(*b*) The map of *Morocco* in two sheets, *No. 170* (North) and *No. 171* (South), on a scale of 1:1,000,000, and which also includes enlargements. This map is at present in process of being brought up to date and renovated. It will be published in one single sheet during the course of the summer as *No. 169*.

FIGURE 2 **The detailed maps** at scales from 1/800,000 to 1/1,000,000

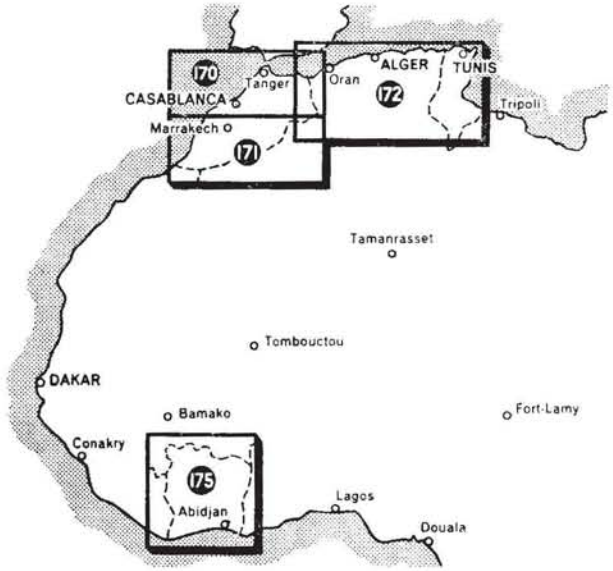


FIGURE 2. *Michelin detailed maps at 1:800,000 to 1:1,000,000*

These two maps are very detailed, although they are on a relatively small scale, as no less than 5 categories of roads, are indicated together with 3 types of highway widths. Conventional signs are numerous and varied (lighthouse, windmill) ksar, souk, marabout, etc.).

In the case of rivers, the type of crossing is always specified: bridge, ferry, ford, etc.

(*c*) Map *No. 175* of the "*Côte-d'Ivoire*" ("Ivory Coast"), scale 1:800,000, the legend of which approximates to that of map *No. 155*. A plan of Abidjan and a descriptive text complete this map.

Organization of the Michelin Cartographic Service

A distinction must be made between the four groups that compose this service: *documentation*, *preparation*, *drawing* and *printing*.

The *documentation* department, which is responsible for co-ordinating all items of information, examines the choice of base maps and draws up the questionnaires to be addressed to the various sources of information:

Public works;

Local authorities;

Central administrations (Customs, hydrographic, hydrological and meteorological services, etc.), geographers and ethnologists, tourist offices, and forwarding agents.

The *preparation* department uses all this information to make up models, which the draughtsman will use to produce his sketch map; the plotting of roads is indicated, the choice of hydrography is made, and the toponomy is shown by an indication of the characters to be employed.

The *drawing* department produces a sketch based on the preparatory work. This sketch, traced in colours on a stable mount, is the representation of the planimetry of the future map. The lettering is delineated on a transparent mount, which is properly aligned.

Proofs on paper are printed off from the sketch to support the complementary documentation assembled on the spot by the Michelin representatives attached to the Trade and Touring Services. The work is very lengthy and very delicate, entailing long months devoted to research, compilation, investigations and visits.

The drawing is then produced in two stages:

(1) Photographic composition and projection of the lettering on a bromophoto by means of a special machine called a "Nomaphot".

(2) Drawing of the outline on this representation of the lettering; the drawings are stereotyped and the films thus obtained are stuck upon glass.

Printing is carried out in offset.

Conclusions

In order to facilitate appreciation of the volume of work involved in producing a map of the type of *No. 155* of format 110 x 125 in 6 colours, scale 1:4,000,000, we considered that it would be useful to provide this table showing the time spent.

Conception: 117 days;

Documentation: 188 days;

Preparation: 250 days;

Sketch drawing: 105 days;

Investigation on the spot: 137 days;

Corrections applied on receipt of the complementary documentation and reports of the investigators: 140 days;

Drawing: 260 days;

Retouching on glass: colouring: 190 days;

With the various work, let us say about 1,600 days.

The perfecting of one single sheet represents, as we see, a considerable amount of work. It necessitates the close collaboration of all the departments concerned. It proved possible, to produce the map of the Ivory Coast, because all the administrative organs of the country placed their services at the disposal of the Michelin Touring Service, in order to produce with them this national document.

We hope that this collaboration, which is already effective in numerous States, may become general, so that Michelin may be enabled to bring to a successful conclusion the work of co-ordination constituted by the whole range of maps published by the Michelin Touring Service. These publications can, in fact, only be an important factor in the unity and prosperity of the economy of the African States.

MEMORANDUM ON PRECISE LEVELLING CARRIED OUT BY FRANCE IN AFRICA[1]

(Communication from the Institut géographique national—Paris)

I. Background

A. *North Africa (Algeria, Tunisia, Morocco)*

We have to get back to the years 1887-1889 for the first geometric levellings in Africa. The traverse lengths used the main lines of Algeria and Tunisia, the datum level having been determined by a mean tide gauge installed in the port of La Goulette.

About 1911 a precise levelling network was established in Morocco, the reference point of which was a tide scale installed in the port of Barcasses at Casablanca.

Until 1914 progress was somewhat irregular, but it was not until 1920 that the polygons really took shape.

On the eve of the Second World War, the Algerian network, which was practically finished, consisted of about a dozen polygons with a total development of 8,000 km, whereas Tunisia and Morocco only had about 4,000 km of levelling each.

That was the position in 1939 with regard to precise levelling in North Africa; it was carried out almost entirely by the Service géographique de l'armée (Army Geographical Service) with the help of instruments that were modern for the time and operational methods offering all the necessary guarantees, for they were similar to the instruments and methods used in the Service du nivellement général (General Levelling Service) of France.

But at that time the Army Geographical Service was unable to complete the work, i.e. to renew certain very old lines, repeat certain polygons with very pronounced closures, or lastly to adjust the most complete Algerian and Tunisian networks so as to give them definite datum levels and heights, because the heights had been calculated as the work proceeded in order to meet the urgent needs of the Public Works Department.

Thanks to the Institut géographique national, the Algerian network was made uniform about 1950. The work done by the teams sent there made it possible not only to fix the closure of the main polygons but also to continue the routes southwards beyond the boundaries of the Sahara. In Tunisia the operations were limited to a route joining the networks to the port of La Goulette where the final choice of datum level was made for the Algerian levelling.

[1] The original text of this paper, submitted by France, under the title "Note sur le nivellement de précision réalisé en Afrique par la France", appeared in French as document E/CN.14/CART/19.

For Morocco, a new, coherent and dense system was set up between 1955 and 1961, as far as the Mauritanian frontier in the south. This network, which comprises first and second order lines observed with the same accuracy, was adjusted as a whole and its heights calculated from a mean zero at Casablanca.

Lastly, since 1958 the Tunisian Topographical Service has been responsible for the re-making of its network, and up to now has carried out 3,000 km of excellent first-order levelling.

B. *Equatorial Africa, West Africa*

A first levelling mission composed of two operators was sent to the Chad region in 1947. Its purpose was no to plot a major base route but rather to carry out partial and fairly dense levelling over a small area in order to meet local needs.

Although the advantages derived from this first mission in "Black" Africa were modest from the point of view of over-all levelling, the interest aroused by the results obtained had the consequence of ensuring the continuity of the operations in the south-westerly direction and giving the embryo levelling a datum level based on a mean sea level. Scarcely two years after the first determination of levels carried out in the heart of the Chad territory, the port of Kribi was reached. Meanwhile a mean tide gauge had been installed there, and although the observations had only been recorded there for a short time, a mean zero was determined, giving an acceptable base for calculating the heights.

Levelling was continued without interruption from 1950 to 1962 at the average rate of 3 missions a year.

In addition to the large first-order polygons covering the territory of Equatorial Africa, and always in order to meet urgent needs, second-order and even third-order traverses were set up.

Observations were made on a second mean tide gauge placed at Pointe Noire, and it is from those observations that the *adjusted and final* heights of the Equatorial African network were calculated.

Side by side with the levelling work carried out in the States of Equatorial Africa, work was commenced in West Africa, this time starting from a tide gauge of the Dakar Hydrographic Service, and it was possible immediately to meet the requests for heights.

From Dakar the network progressed in 3 directions in turn; these are, in chronological order:

1. Southwards to the sea via Abidjan, Conakry and Lomé, where checks by closures on mean zero were made by observations on tide scales;

2. Eastwards to the Chad to join up with the Equatorial African levelling;

3. Northwards, on the one hand to Tindouf, point of junction with the North African network, and on the other hand via two major routes across Niger and the Sahara to the Algerian network (Colomb-Béchar, In Salah).

Thus, considered as a whole, all the African territory is marked out in major base lines, connecting the Mediterranean (Tunis) with the four Atlantic ports Casablanca, Dakar, Kribi and Pointe-Noire.

II. Methods used, conservation of the networks

In addition to accuracy, the main quality required of a modern network is conservation; but in areas which are often marshy and depopulated desert regions where there are no, or very few, main works of lasting materials, the operator has had to construct the boundary marks himself and to dispatch them with the materials needed to install them in the places selected.

The density of these boundary marks varies with the difficulties of access and of supply. Usually a boundary mark has been set up every 5 km, but on certain tracks not usable by vehicles this density is reduced to one boundary mark every 10 km.

For the African territory as a whole this density is adequate, but in order to ensure the best possible conservation of the established network, it would be advisable to consider placing base boundary marks of large dimensions every 50 km for example.

III. Results obtained

The first-order polygons observed are of an average length of 1,500 km and an average closure of 150 mm; this gives a probable kilometric error of about 4 mm per km. This value will be made more accurate in future years when certain sections belonging to polygons with abnormal closure have been recommended and when the junction is effected between certain major routes at present extending to the east of the network.

The junction of the different points of contact with the sea offered a highly efficient means of checking the operations, as well as a subject of justifiable curiosity. In this connexion it is interesting to note, following the shortest and most favourable routes, the following discrepancies between the mean zeros that were calculated:

Between Tunis and Dakar: + 35 cm (Tunis lower than Dakar);

Between Dakar and Pointe-Noire: − 18 cm.

It is also of interest to compare the discrepancies between the mean levels of the points nearest to each other.

Dakar-Conakry: − 9 cm;

Conacry-Abidjan: − 18 cm;

Abidjan-Kribi: + 12 cm;

Tunis-Casablanca: + 23 cm.

Another result shows the excellent concordance of the African levellings. The height of the water level of Lake Chad at a particular moment was calculated starting from Tunis, Dakar and Pointe-Noire by means of the following routes:

Tunis, Ouargla, Fort Flatters, Tamanrasset, Agadès, Zinder, Lake Chad;

Dakar, Bamako, Ouagadougou, Niamey, Zinder, Lake Chad;

Pointe-Noire, Lambaréné, Yaoundé, Garoua, Lake Chad.

The three values found showed a remarkable concordance.

From Dakar: 281 m 68;
Tunis: 281 m 77;
Pointe-Noire: 281 m 89.

It is clear that under these conditions it is possible to contemplate an over-all adjustment of the African block based on three zeros: Dakar, Tunis and Pointe-Noire. This adjustment, which will have to be made in the years to come, will obviate the inconvenience resulting from the existence of blocks side by side and adjusted in isolation.

MEMORANDUM ON HYDROGRAPHIC SURVEYS, SEA CHARTS AND NAUTICAL INFORMATION RELATING TO FRENCH-SPEAKING COUNTRIES IN AFRICA[1]

(Ministère des armées (marine), Service central hydrographique)
(Ministry for the Armed Forces (Navy), Central Hydrographic Department)

A. Surveys and charts

The coasts of Africa were very early the subject of exploratory surveys conducted by French hydrographers, the first in date being that of the coast between Mauritania and the Bissagos Islands in 1816-1817, which led to the publication of charts. Later, numerous detailed surveys, of varying value and intended to meet immediate requirements, were carried out in general in the approaches to ports that already existed or were planned, in the mouths of rivers, and generally speaking in places of access to areas of French influence. From 1860 onwards in Algeria, and from 1880 onwards in the other territories, systematic surveys were organized, which have continued until our own day, in spite of the two long periods of interruption caused by two world wars.

An especially large-scale efforts has been made from 1947 onwards, through the establishment of two permanent hydrographic missions, one for the South Atlantic ("Beautemps-Beaupré") and the other for the Indian Ocean ("La Pérouse"). Finally, a hydrographic mission ("Amiral Mouchez") operated for ten years (1950-1959) on the Atlantic coast of Morocco.

We enumerate below the latest systematic surveys carried out and the state of cartography in each country, as well as future projects. As regards the surveys, it should be noted that until 1920, soundings were carried out solely by means of an olive-shaped lead, a method that was later gradually replaced by sounding with a fish-shaped lead and by echo sounding. After 1947, echo sounding was exclusively employed, and since 1952, when precision radiolocalization equipment was introduced, soundings have been carried out right up to the limits of the continental shelf, and often very far beyond.

I. NORTH AFRICA

1. *Tunisia*

Systematic surveys were resumed between the two wars for the entire Tunisian coast, with the exception of the Gulf of Sfax. They extend about 30 kilometres out from the coast.

The cartography consists of 44 charts:

Five charts on a 1:300,000 scale approximately, published between 1878 and 1890, and reissued in about 1950;

Twenty charts on a 1:60,000 scale approximately, covering all the coasts of Tunisia, which were published in about 1880 and reissued between 1940 and 1960;

Nineteen large-scale charts (on scales of 1:35,000 to 1:10,000) for the ports, anchorages, etc. 13 charts were published in 1970, 9 of which were issued in about 1950 and 6 of which have been published since 1933.

No new work or publication is contemplated.

2. *Algeria*

Systematic surveying was resumed between 1921 and 1933 for the coasts in their entirety, and for the whole area of the continental shelf.

The cartography which was, taken as a whole, somewhat old, has been brought up to date from 1935 until our own day. It includes:

Two charts on a 1:600,000 scale, published in 1935;

Fourteen charts on a 1:100,000 scale, of which 10 were published in 1870 and 4 in about 1940. The majority have been reissued, and the most recent editions date from about 1955;

Eight medium-scale charts, with a scale of between 1:35,000 and 1:25,000, for the approaches to the major ports, published between 1930 and 1940;

Sixteen large-scale charts (scales 1:15,000 to 1:10,000) for ports and anchorages, published in about 1930 and mostly reissued over the last few years.

No new work or publication is contemplated.

3. *Morocco*

(a) *Mediterranean coast*

A survey of 1961 covers the seaward approaches to this coast, but not the actual coastal area.

(b) *Atlantic coast*

A very full survey was carried out from 1950 to 1959, extending from Mehdia in the north to the 30th parallel south of Agadir. This survey extends to 120 kilometres off the coast, reaching in places the isobath of 4,000 metres.

The cartography, based on earlier surveys, is modern and practically complete. All the charts have been published since 1954, with the exception of two published in 1922 and 1929, which have been brought up to date by means of reissues incorporating the most recent work. The cartography comprises:

One general chart on a 1:800,000 scale, which will be published shortly;

Five charts on a 1:150,000 scale, extending from Agadir to Mehdia;

[1] The original text of this paper, submitted by France, under the title "Note sur les levés hydrographiques, les cartes marines et l'information nautique des pays d'expression française en Afrique", appeared in French as document E/CN.14/CART/20.

Sixteen charts on a 1:50,000 scale extending from *Oued* Massa (Wadi Massa), to the south of Agadir as far as Mehdia;

Nine charts on a 1:10,000 scale, showing the ports and roadsteads.

This whole range constitutes one of the most remarkable in the portfolio of French charts. No additional surveys are contemplated, but a further 6 charts are planned:

One chart on a 1:150,000 scale, designed to complete the existing series, and extending as far as Gibraltar;

Five charts on a 1:50,000 scale, completing the present range: 2 extending from Mehdia to the frontier between the former French and Spanish protectorates, 1 to the south of *Oued* Massa, and 2 to the south of the Ifni enclave.

II. FORMER STATES OF THE COMMUNITY ON THE WEST COAST OF AFRICA: MAURITANIA, SENEGAL, IVORY COAST, TOGO, DAHOMEY, CAMEROUN, GABON, CONGO–BRAZZAVILLE

The small-scale cartography comprises, from Mauritania to Guinea:

One general chart on a 1:2,600,000 scale, published in 1870 and reissued in 1948;

Two charts on a 1:800,000 scale, published in 1949 and 1958;

Six charts on a 1:300,000 scale, extending from Cap Blanc to the Sherbo Island, but with a "gap" to seaward of Portuguese Guinea. These charts were published between 1945 and 1962.

A chart on a 1:300,000 scale extending from Rio Nunez to Cap Roxo is planned.

The small-scale cartography from the Ivory Coast to Pointe Noire comprises 4 charts on a 1:1,000,000 scale, published about 1925 and reissued between 1940 and 1960.

1. *Mauritania*

The general survey extending from Port-Etienne to Dakar was carried out between 1934 and 1938, and completed in 1953 and 1955 by the survey of the approaches to Nouakchott. The survey of the Banc d'Arguin (Arguin Bank) was undertaken in 1962 and is continuing: its completion is anticipated for 1964.

The cartography comprises:

Four charts on scales varying between 1:17,500 and 1:78,000 for the approaches to Port-Etienne. 3 were published between 1942 and 1946, and the fourth, published in 1914, was reissued in 1942.

The compilation of 4 charts on a 1:100,000 scale extending from Cap Blanc to Nouakchott is planned.

2. *Senegal*

Surveys that were undertaken in 1936-1937, extending from the Banc de Dakar in a southerly direction, and were interrupted by the war, were resumed in 1948 and now cover the coasts of Senegal in their entirety until depths of 100 to 200 metres are attained, with the exception of a small area south of the Casamance, the survey of which is at present in course of completion. The extension of these surveys to seaward is planned for the coming years.

The cartography comprises:

Three charts on a 1:100,000 scale, extending from Dakar to Cap Roxo, published between 1956 and 1959;

Ten charts, on scales of 1:50,000 and 1:35,000, extending from Dakar to the mouth of the Casamance, and showing the courses of the Saloum and Casamance: 6 of these charts are of later date than 1954, and the 4 others have been reissued recently;

Four charts on scales of 1:5,000 and 1:20,000 showing the main ports and anchorages, published or reissued recently.

A chart on a 1:100,000 scale is planned for Gambia.

3. *Ivory Coast*

The survey of the principal anchorages and of the approaches to Abidjan was carried out between 1948 and 1952. A programme for the systematic surveying of the entire coast was laid down in 1961, and is progressing on both sides of the Vridi Channel as far as the isobath of 50 metres. It will be extended to seaward after 1964.

The cartography comprises:

Two charts on a 1:300,000 scale, published in 1894;

Four charts, on scale of 1:35,000, 1:20,000 and 1:10,000, for Abidjan and important anchorages. One of these charts was published in 1938, and the others quite recently.

The publication is planned of a series of charts on a 1:100,000 scale covering the whole of the Ivory Coast, when the surveys have been completed.

4. *Dahomey–Togo*

The approaches to Cotonou were surveyed in 1952.

The cartography comprises two charts on a 1:300,000 scale published in 1867; and the compilation of a chart on a 1:25,000 scale is planned for the Cotonou area.

5. *Cameroun*

The Wouri estuary and its approaches up to about 40 kilometres to seaward were the subject of surveys carried out between 1948 and 1952.

One chart on a 1:300,000 scale, published in 1910 and reissued in 1930;

Three charts on a 1:100,000 scale, published in 1922 and reissued in 1950;

Two charts on a 1:35,000 scale and a 1:15,000 scale, for the Cameroun estuary and the port of Douala.

No new work or publication is contemplated.

6. *Gabon and the Congo*

The systematic survey undertaken from 1949 onwards has been continued, extending from Libreville in the north and from Pointe Noire in the south. It extends about 70 km to seaward. This survey is now completed from Corisco to the parallel of Iguela, and is in course of completion between Iguela and Pointe Noire.

The old cartography comprises charts published between 1892 and 1938 on scales varying from 1:900,000 to 1:80,000. There are, besides:

One chart on a 1:100,000 scale published in 1960;

Six large-scale charts (scales 1:35,000 to 1:10,000) for the ports, and for entrances to important rivers.

There are in course of completion:

One chart on a 1:100,000 scale;

Two charts on scales of 1:35,000 and 1:55,000.

The following are planned:

Four charts on a 1:300,000 scale, extending from Pointe Noire to the Cameroun;

One chart on a 1:100,000 scale, extending from Cap Esteiras to the Baie du Cap Lopez.

III. OTHER FRENCH-SPEAKING COUNTRIES ON THE COAST OF WEST AFRICA: GUINEA, CONGO-LEOPOLDVILLE

1. *Guinea*

A number of surveys of restricted scope have been carried out since 1942, mainly in the approaches to Conakry (1947 to 1950) and in the approaches to Rio Nunez, extending up to 50 km to seaward (1956 to 1957).

The cartography comprises:

Three charts on the Rio Nunez area on scales on 1:100,000 and 1:35,000, published in 1959 and 1961;

One chart on a 1:120,000 scale, extending from Conakry to the Mellacoree river, published in 1943;

One chart on a 1:70,000 scale of Rio Pongo, published in 1897 and reissued in 1937;

Five charts on scales varying between 1:10,000 and 1:50,000 for the port of Conakry, anchorages and entrances to important rivers, published between 1938 and 1951.

No new work or publication is contemplated.

2. *Congo–Leopoldville*

N.B. The coasts of this country have always been treated in French hydrography as the coasts of a foreign country.

IV. MADAGASCAR

The survey of the coasts of Madagascar was begun in 1893, and continued until 1914 in the area of Diego-Suarez and on the north-west coast of the island. This work was interrupted between then and 1947, since which date a hydrographic mission has been operating continuously along the coasts of this great island. Surveys are in progress simultaneously on the east coast extending from Diego-Suarez in a southerly direction and from Tamatave in a northerly direction, and on the west coast on both sides of Morombe. To these must be added numerous localized surveys: the approaches to Majunga, the approaches to Tulear. With work continuing at its present tempo, about 20 years will be required to complete the hydrographic survey of Madagascar.

The cartography of Madagascar is still incomplete, and is dependent on the completion of surveys. At present it comprises:

Four charts on a 1:850,000 scale, published during the years 1850-1880 approximately, and reissued in about 1950;

Five charts on a 1:300,000 scale, partially covering the west coast, and published between 1909 and 1953;

Thirteen charts on scales of 1:200,000 and 1:100,000 of the north-west coast, published between 1890 and 1910;

Three charts on scales of 1:150,000 and 1:100, 000 of Fort Dauphin and Tamatave, published in 1951, 1961 and 1963;

Nineteen charts on a 1:50,000 scale published between 1960 and 1963, (11 charts for the east coast and 8 for the west coast);

Twenty-one charts on a scale of between 1:50,000 and 1:22,500, for important points on the coast, published between 1890 and 1918, with the exception of one published in 1955;

Eighteen large-scale charts showing the ports, anchorages, etc., of which 7 were published between 1885 and 1918, and 11 between 1943 and 1963.

The following are planned:

One series of 12 charts on a 1:450,000 scale, of which one has been published;

One series of 32 charts on a 1:150,000 scale, of which two have been published and three are in course of completion;

One series of charts on a 1:50,000 scale, of which 19 have been published and two are in course of completion.

V. THE ISLANDS OF THE INDIAN OCEAN

1. *Comoros*

The hydrographic mission for the Indian Ocean has been operating very recently in the Comoros, and the work there will be continued.

The cartography comprises:

One chart on a 1:450,000 scale, published in 1960;

Three charts on a 1:150,000 scale, published in 1959;

Two charts on a 1:35,000 scale, published in 1959;

Two detailed charts published in 1879 and 1893, and reissued in 1951 and 1960.

2. *Réunion*

The approaches to the port de la Pointe des Galets were surveyed in 1950 and 1952.

The cartography comprises:

One chart on a 1:450,000 scale, showing the islands of Réunion and Mauritius, published in 1849 and reissued in 1956;

One chart on a 1:120,000 scale, published in 1849 and reissued in 1956;

Two charts on a 1:40,000 scale, one published in 1849 and reissued in 1950, and the other published in 1959.

No new projects are at present contemplated.

3. *Scattered islands*

In the Kerguelen Islands a survey of the Morbihan Bay was carried out in 1949-1950 and 1956. The cartography of these islands comprises:

One chart on a 1:250,000 scale, published in 1937 and reissued in 1961;
Four detailed charts published between 1938 and 1962.

Compilation of the following is planned:

A chart on a 1:100,000 scale, covering the whole archipelago;
Six charts on a 1:30,000 scale.

The islands of Europa, Juan de Nova, St. Paul, Amsterdan, Heard, MacDonald, Marion, Prince Edouard and Crozet form the subject of charts which have been reissued recently. A small survey was carried out at Juan de Nova in 1953.

VI. FRENCH SOMALI COAST

The exploratory surveys of 1890 were resumed in 1928, 1936-1937 and finally 1956-1957, as far as the approaches to Djibouti and the coast to the north of Obock are concerned.

The cartography is fairly complete, but the small-scale charts (two) and the large-scale charts (two), showing the port of Obock and the anchorages of the Gulf of Tadjura, are old, having been published in about 1890. There are, besides:

Two charts, published in 1929 and reissued in 1961-62, showing the port and roadstead of Djibouti;
Two charts published in 1961, showing the approaches to Djibouti and the Seba Islands.

The compilation of two charts on a 1:150,000 scale is planned to replace the old charts.

B. NAUTICAL INFORMATION

The supply of nautical information is a very pressing matter for the majority of the newly independent countries of Africa. Indeed, any nautical documentation (charts and publications) that is *not corrected up to date is dangerous to navigation*, and numerous accidents, some of which have even led to the loss of ships and of human lives, are attributable to the inadequacy of nautical information, or to the slowness of its transmission, which amounts to the same thing. The quality of nautical documentation and, in consequence, keeping this documentation up to date, are matters involving the safety not only of the ships of the littoral States, but also, above all, of all ships, no matter to what nation they belong, which have cause to navigate in the proximity of the coasts. Therein lies *a moral obligation of international character* for every State.

France had assumed that responsibility for all the States mentioned in the present memorandum until their accession to independence. In so far as the necessary documentation is received, France continues to do so; but it is quite evident that the main source of information cannot be other than national. It is therefore expedient that co-operation in this task should be established, until such time as each State can itself assume responsibility for its nautical information—that is to say, for its assembling and diffusion on a world-wide scale. Exploratory talks are in progress on this subject between the Service hydrographique français (French Hydrographic Department) and the competent local authorities.

THE CONTRIBUTION OF ORSTOM MEDICAL AND VETERINARY ENTOMOLOGISTS (1949-1962) TO THE AFRICAN AND MALAGASY TOPICAL MAP[1]

In medical and veterinary entomology maps are used mainly to represent the geographic distribution of insects and acarides vectors of serious endemic or enzootic diseases. One of the first tasks requested of the research workers of the Office de la recherche scientifique et technique outre-mer (Office for Scientific and Technical Research Overseas) was the compilation of maps of the distribution of the glossinae vectors of trypanosomiasis and the anopheles vectors of malaria, prepared with the symbols recommended by the inter-African Conference on the tsetse and trypanosomiasis (Brazzaville, February 1948) and by the Conference on Malaria in Equatorial Africa (Kampala, 1950; cf. WHO technical report No. 38, 1951). Thanks to inter-territorial scientific co-operation, these works have made it possible to compile comprehensive maps of vectors for Africa south of the Sahara by placing the maps of French entomologists alongside those of foreign entomologists. African epidemiology can learn much from a comparison of these maps with those indicating the distribution of diseases transmitted. More detailed regional maps were then compiled, together with maps of the distribution of other haematophagous arthropods: mosquitoes other than anopheles, sand-flies and onchocerca, horseflies (*tabanidae*), ticks (*ixodidae*), (cf. list of maps given in the appendix).

The compilation of each of these maps has necessitated numerous prospections at different seasons and of as many and as varied capture points as possible, followed by thousands of specific identifications of the arthropod, the chorology of which is studied. It takes several years before the network of information thus compiled is sufficiently complete to give a precise idea of the distribution areas of each vector.

Usually, on one hand the same map symbols are used to show collection points in the case of rare or localized species and conventional colours to show the area of extension of common species.

When numerous species are mentioned by their symbol on the same large-scale map, the map becomes difficult to interpret quickly and the distribution of the main vectors is not clearly shown. To obviate these difficulties, maps are compiled showing only a limited number of important species represented by a sign, a tint or a conventional colour. In order to achieve standardization, the CCTA

[1] The original text of this paper, submitted by France under the title "Contribution à la carte thématique africaine et malgache par les entomologistes médicaux et vétérinaires de l'ORSTOM" appeared in French as document E/CN.14/CART/23.

Conference of Lwiro (Congo, Leopoldville, 1957) recommended the compilation of degree squared distribution maps of the main arthropods and pathogenic molluscs (1 degree squared—approximately 11,000 km²). Up to four different species can be shown on each map. See the *map of West African* glossinae by A. Rickenbach (1961) and the *map of* anopheles *vectors of malaria in West Africa* by A. Escudie and J. Hamon (1961).

So far the medical entomologists have not attempted to compile maps showing the density of the arthropod species they study. The density is indeed very difficult to evaluate and is subject to seasonal and annual variations which would mean that the maps would have to be brought up to date continuously. Modifications in the area of extension of a species can only be estimated by comparing precise distribution maps compiled at intervals of several years. They will make it possible to appreciate the results of control campaigns against the big vectors (*anopheles*, *glossinae*, sand-flies, ticks, and so on).

Research work into medical and veterinary entomology in the field calls for the preliminary compilation of very detailed maps, topographical charts and aerial photographs which are essential to the carrying out of prospections and entomological prophylaxis campaigns. Their success depends, therefore, on close collaboration between geographers, topographers, cartographers and entomologists.

LIST OF THE PRINCIPAL DISTRIBUTION MAPS OF PATHOGENIC ARTHROPODS PUBLISHED BY ORSTOM MEDICAL AND VETERINARY ENTOMOLOGISTS IN AFRICA, MADAGASCAR AND REUNION

1. *West Africa*

1:3,000,000: *Limite des aires de distribution des glossina palpalis et techinoïdes; zones pluviométriques* (Boundary of distribution areas of *glossinae palpales* and tachiaidae pluviometric areas.) 1 sheet. SG/AOF, 1949; *Limite des aires de distribution des glossina morsitans et loogipalpis; zones pluviométriques* (Boundary of distribution areas of the *glossina morsitans* and *loogipalpis*: pluviometric areas). *Ibid.*, 1949.

1:10,000,000 (in degrees squared): *Carte de répartition des anophèles vecteurs du paludisme en Afrique Occidentale* (Map showing the distribution of *anopheles* vectors of malaria in West Africa), by A. Escudie and J. Hamon, SG/Dakar, 1961. Published in *Médecine tropicale: Le paludisme en Afrique Occidentale* d'expression française (Malaria in French-speaking West Africa), 1961, 21, p. 679.

1:10,000,000 (in degrees squared): *Carte de répartition des glossines en Afrique Occidentale d'expression française* (Map showing the distribution of *glossinae* in French-speaking West Africa), by A. Rickenbach, 2 sheets. 1961, ORSTOM and Muraz Centre (Bobo-Dioulasso, Upper Volta).

1:2,000,000: *Carte de répartition des anophèles en Afrique Occidentale, établie sous la direction de J. Hamon* (Map showing the distribution of *anopheles* in West Africa, compiled under the supervision of J. Hamon), *Service cart. ORSTOM*, February 1957, 3 sheets.

Carte de la Casamance avec la répartition actuellement connue des anophèles (Map of the Casamance River Region showing the current known distribution of *anopheles*), by J. Hamon, P. Devemy, A.Rickenbach and G. Causse, ORSTOM and SGHMP d'AOF, published in: *Contribution à l'étude des moustiques de la Casamance*, *Ann. parasit. hum. comp.*, 1956, *31*, No. 5-6, p. 609 (Contribution to the study of mosquitoes of the Casamance River region).

Carte de répartition des anophèles en Afrique occidentale (Haute-Volta), (Map showing the distribution of anopheles in West Africa, Upper Volta), by M. Holstein, J. Hamon and A. Rickenbach, 1955, Serv. cart. ORSTOM. Published in the *WHO Bulletin* 1956; *15*, p. 552.

Carte de répartition des simulies dans le bassin de la Bougouri-Ba en saison sèche (Map showing the distribution of *simulidae* in the Bougouri-Ba basin in the dry season), by M. Ovazza, published in the *Bull. IFAN*, 1958, 20, Ser. A., No. 2, p. 654. (Article by M. Blanc, F. d'Aubenton, M. Ovazza and M. Valade: *Recherches sur la prophylaxie de l'onchocercose en AOF I. Étude hydrobiologique de la Bougouri-Ba et essais de désinsectisation*) (Research into onchocercosis prophylaxis in French West Africa, I. Hydrobiological study of the Bougouri-Ba and attempts at deinsectization).

Carte de la région de Bobo-Dioulasso (Haute-Volta) (Map of the Bobo-Dioulasso region (Upper Volta)), by M. Ovazza, A. Rickenbach and M. Valade, published in: *Tabanidae de la région de Bobo-Dioulasso (Haute-Volta)* (*Tabanidae* of the Bobo-Dioulasso (Upper Volta) region): *Bull. Soc. path. exot.*, 1959 *52*, No. 5, pp. 680-681.

Carte de la Guinée (Map of Guinea), by M. Ovazza, J. P. Adam and H. Bailly-Choumara, 1959, published in: *Contribution à l'étude des Tabanides d'AOF III. Tabanides de Guinée* (Contribution to the study of the *tabanidae* of French West Africa, III. *Tabanidae* of Guinea). *Bull. Soc. path. exot., 52*, No. 3, p. 367.

Carte de la vallée de Yerpao (Dahomey) (Map of the Valley of Yerpao (Dahomey)), by G. Quelennec, published in: *Essais de portée de deux insecticides utilisés contre les larves de Simulium damnosum dans le Nord Dahomey* (Extensive texts of two insecticides used against the larvae of the *Simulium damnosum* in North Dahomey), *WHO Bulletin*, 1962, *27*, No. 4-5, p. 616.

Carte générale de la Côte-d'Ivoire (General map of the Ivory Coast), by J. Doucet, M. Ovazza and J. P. Adam, published in: *Tabanides de Côte d'Ivoire, Ann. parasit. hum. comp.*, 1958, *33*, No. 3, p. 285. (*Tabanidae* of the Ivory Coast, *Ann. parasit. hum. comp.*, 1958, *33*, No. 3, p. 285).

2. *Cameroun*

1:2,000,000: *Carte des glossines du Cameroun* (Map of *glossinae* of Cameroun), by J. Rageau (1949); 2nd edition by J. Rageau and J. P. Adam (1951), Serv. cart. ORSTOM. Published in *Rev. Elev. Med. Vet. Pays trop.*, 1953, *6*, No. 2, p. 76.

1:2,000,000: *Carte des anophèles du Cameroun et notice correspondante* (Map of *anopheles* of the Cameroun and relevant report), by J. Rageau and J. P. Adam, 1952, Ser. Cart. ORSTOM.

Carte de répartition des anophèles au Cameroun (Map showing the distribution of *anopheles* in Cameroun), revised by J. P. Adam in 1955. Serv. cart. ORSTOM. Published in the *WHO Bulletin*, 1956, *15*, p. 553.

Répartition géographique et économique des anophèles au Cameroun: 8 cartes en 2 planches (Geographic and economic distribution of anopheles in Cameroun: 8 two-sheet maps), by J. Mouchet et J. Gariou, published in the *Bull. Soc. Path. exot.*, 1961, *54*, No. 1, pp. 107-108.

Carte des anophèles de la région Bamiléké (Ouest Cameroun) (Map of the anopheles of the Bamileke region (West Cameroun), by J. Mouchet et J. Gariou. Published in *Recherches et études camerounaises 1960, 1*, p. 93.

Distribution géographique et écologique des Glossina palpalis RD et G. fuscipes fuscipes Newst, au Cameroun (Geographic and ecologic distribution of Glossinae palpales RD and G. *fuscipes fuscipes* Newst. in Cameroun), by J. Mouchet, J. Gariou and J. Rageau. Published in the *Bull. Soc. path. exot.*, 1959, *51*, No. 4, p. 653.

Carte de répartition des glossines du Logone et Chari (Map showing the distribution of glossinae of Logone and Chari), by J. Mouchet,

A. Delas and P. Yvore, published in the *Bull. Soc. path. exot.*, 1961, *54*, No. 4, pp. 876-877. (*La campagne expérimentale de lutte contre Glossine tachinoïdes West. à Logone Birni, République du Cameroun et Rép. du Tchad*) (Experimental control campaign against *Glossinae tachinidae* West. at Logone Birni, Republic of Cameroun and Republic of Chad).

Cartes de répartition des ixodidae au Cameroun No. 1, 2, 3 (Maps Nos. 1, 2 and 3 of the distribution of *ixodidae* in Cameroun), by P. C. Morel and J. Mouchet, published in the *Ann. parasit. hum. comp.*, 1958, *33*, No. 1-2, pp. 76-100. (*Les tiques du Cameroun: ixodidae et argasidae*) (Ticks of Cameroun: *ixodidae* and *argasidae*).

Carte des zones de végétation au Cameroun (Map of vegetation areas in Cameroun), by P. Grenier, J. Mouchet, J. Rageau and J.P. Adam, 1960. Serv. cart. ORSTOM published in: *Simulies de la République du Cameroun, Bull. Soc. path. exot. 1961, 54, No. 5, p. 1132.* (Simulidae of the Republic of Cameroun, *Bull. Soc. path. exot.* 1961, *54*, No. 5, p. 1132).

Carte des vecteurs du paludisme (Anopheles gambiae, A. funestus, A. nili, A. moucheti) in 4 couleurs (Map of vectors of malaria (*Anopheles gambiae, A. funestus, A. nili, A. moucheti*) in 4 colours, by J. Mouchet and J. Gariou. To appear in the *Atlas of Cameroun.*

Carte des glossines du Cameroun, en couleurs (Coloured map of the *glossinae* of Cameroun), by J. Mouchet. *Ibid.*

3. *Equatorial Africa*

1:2,000,000: *Carte de répartition des glossines en AEF, 3 feuilles en couleurs* (Map showing the distribution of *glossinae* in French Equatorial Africa, 3 couloured sheets), by L. Maillot, 1956, Serv. cart. ORSTOM.

1,100,000: *Carte de répartition probable des sous-espèces et races de glossina palpalis, région de Brazzaville* (Map showing the probable distribution of sub-species and races of *glossina palpalis*, Brazzaville area), by L. Maillot. 1 sheet, 1956, Serv. cart. ORSTOM.

Carte de répartition des anophèles en AEF (Map showing the distribution of *anopheles* in French Equatorial Africa) by A. Grjebine, 1956. Serv. cart. ORSTOM. Published in *WHO Bulletin*, 1956, *15*, p. 554.

1:2,000,000: *Carte de l'onchocercose humaine dans le sud de l'AEF* (Map of human onchocercosis in southern French Equatorial Africa), by M. Ovazza. Serv. cart. ORSTOM, 1952, published in: *Bull. Soc. path. exot.*, 1953, *46*, No. 4, p. 576 (L'onchocercose humaine et son aspect entomologique dans le sud de l'AEF—Human onchocercosis and its entomological aspect in southern French Equatorial Africa).

Cartes de répartition des tabanides d'AEF (Maps showing the distribution of *tabanidae* in French Equatorial Africa), by R. Taufflieb and P. Finelle. 17 maps published in the *Bull. IEC*, Brazzaville, 1956, No. 12, pp. 211-240.

4. *Ethiopia*

Carte de répartition provisoire des glossines en Éthiopie (Map of the provisional distribution of *glossinae* in Ethiopia), by M. Ovazza. Published in *Bull. Soc. path. exot.*, 1956, 49, No. 1, 206. (*Contribution à l'étude des diptères vulnérants de l'Empire d'Éthiopie*—Contribution to the study of the wounding diptera of the Ethiopian Empire. IV. GLOSSINA).

Carte de Répartition de Simulium damnosum S. Woodi et de l'onchocercose humaine connue en Éthiopie (Map showing the distribution of *Simulium damnosum S. Woodi* and human onchocercosis known in Ethiopia), by P. Grenier and M. Ovazza, published in the *Bull. Soc. path. exot.*, 1956, *49*, No. 1, p. 183. (*Contribution à l'étude des diptères vulnérants de l'Empire d'Ethiopie. II. Simulidae. Simulies et onchocercose*—Contribution to the studies of wounding diptera of the Ethiopian Empire. II. *Simulidae.* Sand-flies and onchocercosis).

Carte de l'Empire d'Ethiopie par le Service cartographique de l'ORSTOM pour le mémoire de M. Ovazaa, J. Hamon et P. Neri (Map of the Empire of Ethiopia by the cartographic service of ORSTOM to be inserted in the memorandum by M. Ovazza, J. Hamon and P. Neri): *Contribution à l'étude des diptères vulnérants de l'Empire d'Ethiopie I. Culicidae*—Contribution to the study of wounding diptera of the Ethiopian Empire, I. *Culicidae*, published (without the map) in: *Bull. Soc. path. exot.*, 1956, *49*, No. 1, pp. 151-182.

5. *Madagascar*

1:1,000,000: *Carte de répartition des anophèles au 1:1.000.000* (1:1,000,000 map showing the distribution of *anopheles*) by A. Grjebine, published in: *Aperçu biogéographique des moustiques de Madagascar et des Comores* (Biogeographical survey of the mosquitoes of Madagascar and the Comoro Islands), *C.R. III PIOSA*, 1957, B, pp. 33-38.

1:500,000: *Carte des anophèles de Madagascar* (9 feuilles) (Map of the *anopheles* of Madagascar—9 sheets), A. Grjebine. *Publ. Inst. Scient., Madagascar* and *Serv. géograph., Madag.*, 1958.

Carte de répartition approximative d'anophèles funestus et d'anophèles gambiae à Madagascar (Map showing the distribution of *anopheles funestus* and *anopheles gambiae* in Madagascar) (Oct. 1955), by A. Grjebine. 2 maps published in *WHO Bulletin*, 1956, *5*, p. 602.

6. *Réunion*

5 cartes en couleurs annexées au Rapport sur la lutte antipaludique à la Réunion, Campagne 1950-1951 (5 coloured maps appended to the Report on the anti-malarial campaign in Reunion, Campaign 1950-1951) by J. Hamon; published by the *Direction départementale de la Santé de la Réunion* (Departmental Division of Health of Reunion). Printing Mme. F. Cazal, Saint-Denis (Reunion), 1951.

Cartes de répartition des moustiques de l'Ile de la Réunion (Maps showing the distribution of mosquitoes on the Island of Reunion), by J. Hamon. 5 maps published in the *Mémoires de l'Institut scientifique de Madagascar* (Memoranda of the Scientific Institute of Madagascar), series E. 1953, *IV*, pp. 525-528.

7. *Africa* (general map)

1:20,000,000: *Carte de répartition de Simulium damnosum, S. neavei et de l'onchocercose humaine* (Map showing the distribution of *Simulium damnosum, S. neavei* and human onchocercosis), by R. Taufflieb, 1951.

We would also draw attention to the *Notes de cartographie* (cartographic notes) by F. Fournier and J. L. Houpeau, roneo ORSTOM and IDERT (Bondy), December 1952.

STUDY AND SUMMARY OF THE CARTOGRAPHIC ACTIVITIES OF ORSTOM IN AFRICA[1]

(Office de la Recherche Scientifique et Technique Outre-Mer)

The Cartography Service of ORSTOM is a general service available to all Departments, Centres and Institutes, Missions and individual research workers whose tasks involve the use of maps as a means of expression.

The headquarters of the Office are at the Bondy Scientific and Technical Centre.

Its work consists of the graphic representation, on topographic base maps furnished mainly by the Institut géographique national, of the results supplied by the research workers in various scientific disciplines: social sciences, medical entomology, phytogeography, pedology and land utilization, geophysics, hydrology, oceanography, climatology.

The difficulties to be solved are complex, owing to the diversity of these disciplines, the scales and the extreme geographical dispersion of the research-workers. It is the cartographer who, in collaboration with the scientists, has to see that the graphic representations are uniform and co-ordinate the legends so as to harmonize as far as possible the work relating to regions that are often far distant from each other: one example is provided by the uniform aspect of the soil survey maps at the two-millionth scale of the Ivory Coast and Cameroon. The processing of the frequently complex documents entails continual communications between the scientist and the cartographers responsible for the presentation of his work.

So far the Service has published nearly 430 maps at large, medium and small scales for Mauritania, Senegal, Guinea, Ivory Coast, Upper Volta, Mali, Dahomey, Niger, Cameroon, Chad, Madagascar, Morocco and Tunisia.

The work done is in the form either of general inventories covering geographical units, sometimes inter-State ones, or of regional studies effected at the request of the States on whose territories ORSTOM is working. These regional studies, carried out under agreements, often have to be completed within a very short time so as to meet immediate or forthcoming development needs.

Principal cartographic work carried out in Africa

Morocco

Sixteen soil survey maps of Casier or of Périmètre, at scales from 1:20,000 to 1:50,000.

Tunisia

One soil reconnaissance map at the scale 1:200,000.

Under the agreement with ORSTOM, preparation in 1962 of:

Two soil survey maps, Enfidaville and Bou Arada, at the scale 1:50,000.

Three land capability maps in terms of dry or irrigated agriculture at the scale 1:50,000.

Mauritania

Eight survey maps of the Brakna basins—1:10,000 to 1:20,000 scale—1959.

One soil survey map of the Guidimaka at the scale 1:200,000—1961.

Two gravimetric maps at the scale 1:1,000,000—1958 and 1962.

Five social science maps (nomadization, movements of herdsmen, principal routes and traiding centres) from the scale 1:300,000 to 1:2,000,000—1950.

Senegal

Land utilization map of Casamance at the scale 1:20,000—1954.

Soil survey map of the Cape Verde peninsula—1:50,000 3 sheets—1959.

Diagrammatic soil survey map of the Djeuss and the Bifeche—1:200,000—1950.

Soil survey map of the Niayes—6 sheets at the scale 1:10,000—1962.

Soil survey map of the Dahra-Djoloff at the scale 1:20,000—1962.

One gravimetric map—Falémé at the scale 1:1,000,000—1961.

Two vegetation maps: Louga, Thiès, at the scale 1:200,000—1956 to 1960.

One vegetation map of Lake Tamma at the scale 1:20,000—1962.

Ten social science maps (population, ethnic groups, density of sheep, goat, horse, donkey and camel herds) at a scale from 1:1,000,000 to 1:3,000,000—1950.

Guinea

Preparation of 13 diagrammatic soil survey maps from 1:2,000 to 1:20,000 and 2 land utilization maps (from 1948 to 1957).

Ivory Coast

Nine soil prospecting and survey maps from the scale 1:4,000 to 1:10,000.

One soil survey map at the scale 1:2,000,000—1961.

Five soil survey and land utilization maps of Tabou and Bérébi at the scale 1:50,000, 1963.

One map of the distribution of Religions at the scale 1:1,000,000—1960.

One vegetation map—Bouaké—1:200,000.

Two gravimetric maps at the scale 1:1,000,000—1959.

Upper Volta

Twenty-six local soil survey maps ranging from 1:5,000 to 1:50,000, compiled in 1960 and 1961, under agreements entered into with that State.

One gravimetric map at the scale 1:1,000,000—1963.

Mali

Three schematic soil surveys—1950.

[1] The original text of this paper, submitted by France, under the title "Examen et bilan sommaire des activités cartographiques de l'ORSTOM en Afrique", appeared in French as document E/CN.14/CART/24.

Four soil survey maps in 1961: from 1:10,000 to 1:50,000 (Samenko, Segala, Soubasso).

One gravimetric map of Western Soudan. Bouguer anomaly—1:1,000,000 in 1958.

One provisional magnetic map of North Soudan—1:1,000,000—1958.

Niger

The following have been compiled:

One soil survey map of the plain of Kolo in 1956 at the scale 1:7,500.

Three soil survey maps (Say and Koulou) at 1:10,000—1960.

Three soil survey maps (Adouna, Keita, Taboye), 1:5,000—1962.

Map indicating the plans of soil survey observations of the Ader Doutchi—1:200,000—1962.

Gravimetric reconnaissance map of Western Niger, Bouguer anomaly—1:1,000,000—1957.

Gravimetric reconnaissance map of Western Niger (Gao-Niamey)—1:1,000,000—1958.

On plant geography, 1 vegetation map has been compiled: Diafarabé—1:200,000—1955.

Dahomey

Compilation of:

Three soil survey maps at the scale 1:100,000 and 1:200,000 (station of Niaouli and delta of the Ouémé in 1947 and 1955).

Three soil survey maps—Agonvy and Agamé—1:10,000 and 1:20,000 in 1962.

Three land utilization maps—Agonvy and Agamé—1:10,000 and 1:20,000—1962.

Two maps, soil survey and land utilization, Boukombé, 1:20,000—1963.

One provisional gravimetric map—1:1,000,000—1956.

Togo

Compilation of soil survey maps: region of Kolokopé, 1:5,000 in 1948; Bayenné, 1:10,000 in 1949—soil prospecting: Sotouboua, Mono, Goubi, 1:100,000 in 1952; Akebo, north Akposso, at the scale 1:250,000 in 1952; Soil survey sketch map of East-Mono, 1:100,000 in 1955.

Provisional soil survey map, 1:1,000,000, 1962.

Chad

Six geological sketch maps: Divo Oumé, Middle Logone, 1:500,000, 1:1,000,000 from 1952 to 1958.

One geological sketch map of the Eré-Loka zone, 1:100,000 in 1960.

Five soil survey maps, Division A north Bongor, 1:20,000 in 1958.

Five soil survey maps of the south-east and north banks of Lake Chad from Tourba to Bol and of the depression of Bahr el Ghazal from Massakory to Moussoro, 1:100,000, 1959.

Five soil survey maps of Chari-Logone and Middle-Logone, 1:200,000, from 1952 to 1954.

Several pedological studies at the scale 1:50,000: Eré-Loka in 1960, Loka-Kabia 1961, Satégui-Deressia in 1962, together with surveys of vegetation, crops and soil capability at the scale 1:100,000 for the same areas, 11 maps in all.

To be noted also: in the social sciences, a study of population settlement in the Middle Logone at the scale 1:500,000 and a map of the ethnic groups of the Mayo-Kébi region at the scale 1:1,000,000.

Cameroon

A series of soil survey maps compiled from 1951 to 1958, ranging from 1:25,000 to 1:500,000.

Two soil survey maps: Kalfou and Maroua, 1:100,000, 1963.

Anopheles mosquito maps in 2 sheets, 1:200,000, 1952.

Tsetse fly map in 3 sheets, 1:2,000,000, 1951.

Anopheles mosquito map, 1:2,000,000 in 1955.

The first part of the Atlas of Cameroon (physical part) has also been compiled; it includes climatology (pro parte), geology, oro-hydrography, soil survey and phytogeography at the scale 1:2,000,000.

Central African Republic

Soil survey and land utilization maps of the peasant holdings of Kembé and the Bambari station in 1958, at the scale 1:10,000, and of the Bahr-Azoum valley at the scale 1:200,000 in 1952.

Ethnic map: Bangassou, 1:1,000,000, 1962.

Congo

A series of soil survey maps of the Niari valley, 1:100,000, compiled in 1952.

Three ethno-demographic maps: Brazzaville, Pointe-Noire, Ouesso, 1:1,000,000, 1955 and 1962.

Madagascar

The Institute of Scientific Research of Madagascar has also published a number of maps.

Special soil surveys have been carried out in connexion with the plans for developing regional units: Lake Alaotra area, valley of the Mandrare, Mangoky delta, Morondava plain, Lower Menarandra valley, territory of Androy. On the basis of these surveys, soil survey maps at a medium or large scale (1:50,000—1:20,000—1:10,000) have been compiled, and soil utilization maps at the scale 1:20,000 and 1:5,000 (20 maps published).

The series forms part of two general soil maps:

The 1:200,000 series in 65 sheets, in progress since 1947: 15 sheets published the 1:1,000,000 at present in preparation, the publication of which is scheduled for 1954.

Also to be noted:

A gravimetric map at the scale 1:2,500,000—1953.

One map of *anopheles* mosquito distribution in 10 sheets at the scale 1:500,000, 1958.

GENERAL MAPS AND SURVEYS

Gravimetry

Map of the magnetic bases of West Africa, at the scale

1:5,000,000, 1958 (including variation, total field, horizontal component, vertical component and dip).

Magnetic map of Equatorial Africa, 1:2,500,000, 1956, including: anomalies of the vertical component, anomalies of the horizontal component, anomalies of the deviation, vertical component and horizontal component.

Gravimetric map of West Africa, 1st edition, 1:5,000,000 in 1950 (isostatic anomalies, Airy's hypothesis, in 3 colours).

Gravimetric map of West Africa, 2nd edition, 1:5,000,000 in 1963, 3 colours.

Entomology

Map of human onchocercosis in southern Equatorial Africa, 1:2,000,000, 1952.

Map of anopheles mosquito distribution in West Africa, 1:2,000,000 1957 (3 sheets).

Map of tsetse fly distribution in Equatorial Africa, 1:2,000,000, 1952.

Map of probable distribution of *Glossina palpalis* and *Glossina fuscipes* in Equatorial Africa, 1:2,000,000, 1957 (4 sheets).

Two maps of tsetse fly distribution in West Africa, by degrees-square, 1:10,000,000, 1961.

CARTOGRAPHIC WORK IN PROCESS OF BEING COMPLETED

Among the work now in progress, mention should be made of a general survey, such as the *Vegetation Map of tropical West Africa.* Longitude 0° east to 18° west, latitude 4° south to 16° north, in 9 sheets at the scale 1:1,000,000.

The second, economic, part of the *Atlas of Cameroon.*

Shortly, during 1963, there will be published:

A soil survey map at the scale 1:500,000 of Niger: Zinder.

A soil survey map at the scale 1:100,000 of Niger: Ader Doutchi.

A soil survey map at the scale 1:100,000 of Senegal: Siné-Saloum.

Six soil survey maps at the scale 1:200,000 of Chad.

Soil survey and land utilization maps at the scale 1:50,000 of Tunisia: Grombalia.

A soil survey map at the scale 1:100,000 of Cameroon: Kaélé, under Conventions entered into with those States.

The work at present in course of preparation on the initiative of ORSTOM will be issued later, namely, general soil survey maps at the scale 1:1,000,000 (1964).

GEOLOGICAL MAP OF NORTH-WEST AFRICA[1]

(Second edition)

Ministère de l'éducation nationale, Centre national de la recherche scientifique, Centre de recherches sur les zones arides
(Ministry of National Education, Cational Centre for Scientific Research, Research Centre for the Arid Zones)

The first edition of the geological map of north-west Africa was published on the occasion of the 19th International Geological Congress (Algiers, 1952). As this edition is exhausted, and as geological study of the Sahara has made considerable progress, it has been decided to compile a second edition, the preparation of which has been entrusted to the Centre de recherches sahariennes (CNRS) (Centre for Saharan Research).

In 1961, two sheets of the south (western Sahara and central Sahara) were compiled, but their printing was delayed owing to budgetary considerations. They are at present in process of being printed, and should be issued before the end of June. The two sheets of the north will only appear two years from now. This second edition is published by the Centre national de la recherche scientifique, with the participation of the Organisation commune des régions sahariennes (Joint Organization for the Saharan Areas) and with the collaboration of the Association des services géologiques africains (Association of African Geological Services).

These sheets were compiled from information contained in the published and unpublished works of a large number of services, of oil companies and mining companies, and of numerous geologists whose names are listed in the margin.

The sheet "Sahara occidental" ("Western Sahara") was prepared by P. Gevin. On the sheet "Sahara central" ("Central Sahara"), the Crystalline period was compiled by M. Lelubre, the Paleozoic by J. M. Freulon, and the Mesozoic and Cenozoic by J. P. Lefranc.

We were not in a position to make the necessary corrections to the topographical base map, the plate for planimetry having been omitted from the second edition.

[1] The original text of this paper, submitted by France, under the title "Carte géologique du Nord-Ouest de l'Afrique", appeared in French as document E/CN.14/CART/25.

PROGRESS ACHIEVED IN THE MAPPING OF AFRICAN SOILS AS A RESULT OF THE INVESTIGATIONS CARRIED OUT BY ORSTOM RESEARCH WORKERS[1]

1. Soon after the war (1945) ORSTOM soil scientists began to deal with the preliminary surveys for the drafting of mapping material (outlines, sketches and maps). Such material was and remains part of the basic elements required by any rational development scheme. Resulting from research work carried out both in the field and in the laboratory, it leads either directly or by means of soils utilization maps to practical conclusions stressing the existing possibilities, i.e.: utilization, outlay and improvement of land.

2. The important and urgent tasks which the ORSTOM first research workers had to cope with, at the outset, have led them to develop rapid and safe methods.

Thus, exploration in the field and use of topographical maps were completed very soon, photo-interpretation being, at times, partly used as a substitute for both, and probably for the first time, in 1948, in French-speaking Africa (Senegal).

The Cape Verde Peninsula soils map, 1:50,000 scale (3 sheets) was carried out in 1953 according to the above method, the latter consisting essentially of "a systematic analysis of the elements related to the physiographic characteristics of soil series, following the study of correlations in the field and adaptation of criteria during exploration".

Since then, and still more since 1958, photo-interpretation has been increasingly applied, specially in West Africa, in Chad and in Madagascar, for maps at the following scales: 1:5,000, 1:10,000, 1:20,000, 1:50,000 and from these for other maps at 1:200,000, 1:500,000, and 1:1,000,000 scales.

Large-scale (up to 1:50,000) aerial photos have been mostly used for spotting in the field and for outlining soil boundaries; medium scale (from 1:50,000 up to 1:200,000) have been used to pick out physiographic units to be studied comprehensively in the field. As from the 1:200,000 scale certain drafts have been selected as controls whilst inter- and extrapolation methods have been referred to.

3. Methods being gradually improved, the work undertaken was carried out in close relationship with the immediate requirements of the various States. At the outset, however, urgency and geographical scattering have not always helped towards a systematic progression of the different patterns of maps. Leaving aside a very small number of general outlined drafts (rather more hypothetical working methods than syntheses), the trend has led to local surveys on a large and very large-scale, which, whilst meeting the concrete needs expected by the applicants, contributed elements concerning explorations tending towards mapping at medium and small scales and covering geographical units, as required for the planning of regional development schemes.

Such circumstantial surveys have, by no means, come to an end: they are still urgently needed, but experience, together with the work achieved to date, and surveys of a more general pattern connected with some projects of major importance make it possible, from now on, to carry them out in terms of more accurate soils classifications and of coherent mapping assemblage.

4. Before exposing the broad lines of the progress achieved to date in the mapping of soils in French-speaking Africa, it should be stressed that ORSTOM participated in every case in the drawing of the maps mentioned below, e.g.:

Sometimes as fully and directly responsible: survey in the field, model drafts carried out in successive order, printing under direct supervision of its own mapping Division;

Sometimes in co-operation with Government or private organizations, ORSTOM's research workers being entrusted with the surveys and the mapping Division with the printing; and

Sometimes, in any one of these cases, model draft being developed and completed, on the spot, by research workers from other organizations following ORSTOM's soil classification and graphic transcription methods.

Furthermore, ORSTOM is scientifically and technically responsible for the completion of the major part of the maps of a final pattern. It is mainly these that are mentioned in the following list, which is by no means exhaustive.

I. Tropical West Africa

(a) *Senegal*: 12 large-scale maps (1:10,000, 1:20,000, 1:25,000), concerning the South (Casamance), the Coast (Niayes), West-Central (Bambey, Boulal, Kolda, Dahra);

The 1:50,000 scale has been adopted for the mapping of Senegal's pseudo-delta and the Cape Verde Peninsula (in this case, with soils utilization maps);

The 1:100,000 and the 1:200,000 scales are for: the M'Bour-Fatick Region and the Senegal delta;

In 1958 a provisional synthesis at a 1:1,000,000 scale covered the whole territory of the Republic; it had been preceded by a 1:500,000 scale map, a third edition of which is in print.

The present aim is to cover the whole territory at 1:200,000 scale beginning from Casamance.

(b) *Mauritania*: the main achievements are, for the time being, limited to 8 maps at 1:10,000 and 1:20,000 scales covering the Brakna low-grounds (Cercle d'Aleg), and 1 map at 1:200,000 scale for the Cercle du Guidimaka.

(c) *Guinea*: only large-scale (1:5,000 and 1:20,000) maps have been done, concerning mainly the pilot district and sub-district of Timbi.

(d) *Mali*: maps published to date refer mainly to the Samenko Plains (2 sheets), Segala at 1:10,000 scale and to Sourbasso (1:50,000).

[1] The original text of this paper, submitted by France, under the title "État d'avancement de la cartographie pédologique en Afrique d'après les travaux des chercheurs de l'ORSTOM", appeared in French as document E/CN.14/CART/45.

(e) *Upper Volta*: in view of the urgent question of the food crops, the surveys undertaken have been strictly localized and maps in accordance are at 1:10,000 and 1:5,000 scales (covering a total of 50,000 hectares of low-grounds and valleys scattered throughout the territory).

However, soils inventory at 1:200,000 scale starts (1963) in the valleys of the White and the Red Volta.

(f) *Ivory Coast*: started in 1946, large-scale maps cover approximately 300,000 hectares: agricultural stations, exploration of soils appropriate to banana and cocoa cultivation (lower and central valley of Bandama), floodable plains suitable for rice cultivation and experimental catchment areas. Surveys at a 1:50,000 scale, based on photo-interpretation, have been undertaken in the south-west (Tabou), and are to be extended towards Sassandra. On the scale of 1:200,000 (1st survey completed in 1949, Bia-Basin, now extended to the south-east (13,000 km^2).

As from 1960, an initial synthesis, at a scale of 1:2,000,000 covered the whole country. Meanwhile another survey on a scale of 1:1,000,000 is being prepared.

(g) *Togo*: detailed local surveys concerning some ten agricultural stations in the south (Sio Valley) and the north. Soil maps at 1:10,000 and 1:20,000 scale are mostly coupled with soils utilization maps;

The 1:50,000 scale includes sheets concerning East Mono and more detailed surveys for the south (Terres de Barre);

The 1:200,000 scale covers the whole south (Terres de Barre), East Mono and on the plateaux, the Adélé-Akposso district;

A provisional synthesis, at 1:1,000,000 scale dating from 1962;

Planned and submitted to the United Nations Special Fund, projects due to cover:

600,000 hectares at a 1:200,000 scale (out of which 300,000 hectares in the Centre)

450,000 hectares at a 1:50,000 scale (out of which 250,000 in the south).

(h) *Dahomey*: the surveys entrusted to ORSTOM cover:

40,000 hectares at 1:10,000 and 1:20,000 scales (including maps for Agonvy, Agame, Guezin, Boukoumé).

70,000 hectares at 1:50,000: Mono, Dongas, Bassiba-Pira.

A general sketch covering the lower valley of the Ouémé, at the scale of 1:200,000.

In preparation, a provisional synthesis at the scale of 1:1,000,000.

(i) *Niger*: following several local detailed surveys (from scale 1:5,000 to 1:10,000) covering 7 sheets (major river valley, Ader Doutchi, etc.), soil scientists have entrusted the Mapping Division with a survey of the eastern part at 1:500,000 (now in preparation); to be carried out within shortest delay: maps of the western part at 1:500,000 scale.

II. Central and Equatorial Africa
(western part)

(a) *Chad*: the surveys carried out, in succession, by the Research Workers from the "Commission scientifique du Logone-Tchad' et du Centre de recherches tchadiennes" concerned the alluvial Logone-Chari-Chad Basin, the Bahr-el-Ghazal and the East Central.

Detailed maps (1:20,000): Casier A Nord Bongor (5 cheets);

Maps (1:50,000: Eré-Loka; Loka-Kabia; Sategui-Deressia (with supplementary maps indicating: vegetation, crops and soils appropriation);

Maps (1:100,000): south-eastern and northern Chad's borders from Tomba to Bol and a Bahr-El-Ghazal low-ground from Nassakori to Moussoro (5 sheets);

Maps (1:200,000): 5 published (Chari-Logone and Moyen-Logone); 6 in print (Fort Lamy—Mogroum–Massénya–Oum-Hadjer–Abéché–Biltine; 9 to be prepared in near future, and 8 to be published later.

Programme for the current year includes the establishment of 9 draft-models. A synthesis at 1:1,000,000 will also be carried out in 1963/64.

(b) *Federal Republic of Cameroon* (East Cameroon only):

Since 1950, major part of surveys has been specially concerned with regions where demographic and economic problems have reached an acute stage (west, north, centre).

From 1:10,000 to 1:25,000 scale: approximately 140,000 hectares have been covered with 20 maps concerning plains (west: Loum and north: Logone) and agricultural districts and farms;

At 1:50,000 scale: 8 sheets (455,000 hectares) mostly concerning Western Mountain region;

At 1:100,000 scale (North Cameroon), between Mora and Guider latitude: 4 sheets have been published; 3 are being published;

The 1:200,000 maps carried out by soil scientists from the "Commission scientifique du Logone Tchad" cover the part of the sedimentary peri-Chadian basin belonging to Cameroon (4 sheets).

In preparation: 4 sheets at 1:50,000 scale (Bidzar, Guider, Boula-Ibi, Pitoa), a 1:200,000 scale map covering Nanga-Eboko-Bertoua and an initial synthesis at a 1:1,000,000 scale covering the whole East Cameroon.

It should be stressed that the preceeding synthesis on the scale of 1:2,000,000 is included in the first volume of *Cameroun Atlas*.

(c) *Central African Republic*: soil cartography, whether provisional or final, relates mostly to the west and south of this State.

Among the large-scale (from 1:10,000 to 1:20,000 scale, most of them not printed yet) 20 maps concerning "paysannats" agricultural stations and rural communities;

Among the 1:100,000 and 1:200,000 scales, 5 maps connected with local surveys, i.e. "paysannats" in the west and the south, and 4 outlining sketches of districts (Nola, Boda, M'Baiki, Dekoa);

A pedo-botanic synthesis of the "Grès de Carnot"-region is available at the 1:500.000 scale.

Mostly provisional, the above maps together with complementary surveys, will be basic to the drafting of a 1:1,000,000 scale map of the Central African Republic due to be published in 1964.

(d) *Congo* (Brazzaville): in order to meet immediate land improvement requirements, mapping of Congo soils

has also, as in the preceding, been oriented towards the large-scales (paysannats, grants, farms...), i.e.:

From 1:2,000 to 1:40,000 scale = 8 maps;

At 1:50,000 = 2 maps (one of which refers to the Movindi central valley, together with soil use maps);

At 1:100,000: 3 sheets concerning the Niari valley;

At 1:200,000: map of "Waterfalls Plateau".

Special reference is made to existence of 2 provisional sketches at 1:2,000,000 and 1:5,000,000 scales, referring to the soils of the Republic of the Congo.

In preparation or projected:

Mapping of the East-Sibiti zone (South Congo) at a 1:500,000 scale;

Map at 1:50,000 scale of the Niari Valley;

A provisional soil map is due to appear, in 1963, in the *Congo Atlas*.

III. Madagascar

In this country, soil maps have been published by the Institut de recherche scientifique de Madagascar (ORSTOM) and printed by the Service géographique de Madagascar. Small-scale maps (including the 1:50,000) published, to date, amount to approximately 20. These meet the requirements for the development of definite regional areas, such as: Lake Alaotra, Mandrare valley, Mangoky delta, etc.

These maps (mostly 1:10,000 and 1:20,000) are coupled with soil utilization maps at 1:20,000 and 1:5,000 scales. Soils inventory at 1:200,000 scales should, finally amount to 65 sheets, 15 of which have been published since 1949. In preparation, a synthesis at a 1:1,000,000.

IV. North Africa

(a) *Morocco*: ORSTOM research workers have, either alone or in co-operation with local public services, carried out 16 detailed maps from the 1:20,000 scale to the 1:50,000 scale (Doukkala Plains, Zebra, Haouz of Marrakech...);

(b) *Tunisia*: in accordance with the Convention passed with the Tunisian Government, the ORSTOM Team carried out, in 1962:

Two maps at 1:50,000 scale (Enfidaville and Bou Amada);
Three maps concerning soils appropriation in terms of dry farming or irrigated cultivation at the same scale.

These maps have been drawn and printed under the technical supervision of ORSTOM's Mapping Division.

To be mentioned, under the same conditions, an exploration map at a 1:200,000 scale.

REPORT ON CARTOGRAPHIC ACTIVITIES IN GHANA[1]

General

The Survey Division of the Ministry of Communications and Works is the national mapping agency of Ghana and is responsible for all land surveys and mapping. The organisation carries out all official surveys and supervises work carried out by licensed surveyors. Its main functions are:

1. Framework control surveys.
2. Topographical mapping.
3. Large scale mapping of towns.
4. Cadastral and engineering surveys.
5. Map reproduction.
6. Training.

Framework control surveys

The country is well covered with a network of triangulation in the South. In the North and in the forest areas of the South where triangulation is difficult and uneconomic controls have been provided by means of primary traverses. Primary levelling net-work is at present very sparse and plans are in hand to extend these to provide adequate height control over the entire country.

Topographical mapping

Regions of Ghana south of latitude 7½° N are well provided with topographical maps at various scales, the 1″ and ¼″ to the mile being popular. Areas north of this latitude have up to 1950 not been adequately mapped. A start was made in that year by the Directorate of Overseas Surveys in co-operation with the Survey Division under the United Kingdom/Ghana Mutual Assistance Scheme to provide 1:50,000 maps with 50-ft. contours for the area by aerial survey methods. The work is progressing satisfactorily and a team of Ghanaian surveyors working under a United Kingdom surveyor is providing dense height control using altimeters. Original photographs taken by the Royal Air Force in 1950 are being replaced by recent ones flown by Messrs. Hunting Surveys Ltd. of England.

Large scale mapping

A major activity of the Division is the tracing of the 280-ft. contour which would mark the eventual limit of the Volta Lake when the Volta Dam is built. The perimeter of the lake is estimated at 4,000 miles. The demarcation of the 280-ft. contour is necessary for planning of new settlements, planning of new roads etc. A number of resettlement sites have been chosen and surveyed and others are being planned. Satisfactory progress has been made with the demarcation of the flood limits. All important areas to be affected have been marked.

Town surveys

The main towns and cities including Accra, Kumasi, Sekondi-Takoradi, Tamale and Ho have been mapped by photogrammetric methods at the scale of 1:2,500 in addi-

[1] The original text of this paper, submitted by Ghana, appeared as document E/CN.14/CART/87.

tion to existing partial mapping at 1:1,250. The programme for survey and revision is being extended to include the smaller towns and villages.

Cadastral surveys

Rigid ground surveys purporting to define boundaries with accuracy are required for attachment to legal documents for leases and acquisitions. All cadastral survey records including surveyors' field books, computations and plans are kept in the Division's record store after examination and approval by the Division.

Engineering surveys

Work is in hand for providing maps for hydroelectric projects on the Pra and Tano Rivers in addition to the Volta River project. Plans are also being prepared for transmission lines and geological prospecting.

Map reproduction

The reproduction section is one of the most up-to-date establishments in the specialised work of map making and maps have been prepared here for other West African countries.

Training

In co-operation with the Kwame Nkrumah University of Science and Technology the Division organises its own training courses for technical as well as professional officers. Candidates with the Cambridge School Certificate or its equivalent with credits in mathematics, physics and another science subject are trained for 3 years in basic surveying to qualify for appointment in the technical grades as assistants. Candidates with higher qualifications ranging from Higher School Certificate to degrees in science are offered scholarships to do the first professional examination and intermediate of the Royal Institution of Chartered Surveyors. Successful candidates continue to take the final R.I.C.S.

The Division also runs a school for cartographic Draughtsmen for all government establishments employing this type of officer, e.g., agricultural division, geological, lands secretariat and town planning. The course is residential for 9 to 12 months and is followed by 12 months' in-service training in the candidates' department.

Organisation

The Survey Division comprises the following sections: headquarters, drawing section, examination and data section, computing and research section, reproduction section and the field or regional sections. The chief survey officer is the head of the department. He is assisted by a deputy chief survey officer and an assistant chief survey officer in the Administration. There is provision for 4 assistant chief survey officers to man the regional headquarters in the Eastern, Ashanti, Northern and Volta regions. The drawing office is under a chief draughtsman assisted by two assistant chief draughtsmen and supervising draughtsmen. The Reproduction Section is similarly run.

Technical services

In addition to providing basic maps and plans for the State and other public bodies and corporations, the Survey Division provides survey data to engineering firms and licensed surveyors. Minor repairs and adjustment of surveying instruments are carried out for the public as well as the standardisation of field tapes.

Current programmes

Major items in this year's programme include surveys for the Volta River project and resettlement sites, mapping of Northern Ghana, primary levelling, mapping of dam sites for the Pra and Tano Rivers, mapping of small towns and villages and the provision of adequate buildings for headquarters and connected sections at Accra.

Problems encountered

In addition to the need for adequate funds, our main problem is shortage of qualified personnel in the computing and photogrammetric sections and a sufficient number of technical staff to carry out the increasing number of surveys required for development whilst the existing administrative as well as technical office accommodation make the expansion of the services of the Division to cope with demands impossible.

REPORT ON CARTOGRAPHIC ACTIVITY IN KENYA, 1950-1963[1]

Report by the Survey of Kenya

General

This report is a brief description of cartographic and related activities in Kenya since 1950.

The Survey of Kenya which was founded in 1906, is the department of the Kenya Government responsible for all major cartographic activity in Kenya. In the fields of primary and secondary triangulation and medium and small scale topographical mapping, valuable assistance has been received during the period under consideration, from the Directorate of Overseas Surveys (DOS), a branch of the British Department of Technical Co-operation, and from the British Army.

Emphasis is placed in this report on aspects of survey in

[1] The original text of this paper, submitted by Kenya, appeared as document E/CN.14/CART/4.

Kenya which have particular relevance to the country's developing social and economic needs.

Geodetic surveys

(a) *Major and secondary triangulation*

The original major triangulation of Kenya, carried out between 1906 and 1922 to standards of accuracy which are appropriate at that time, was by 1950 inadequate for modern purposes.

The DOS, in co-operation with the Survey of Kenya and the equivalent government departments in Uganda and Tanganyika, therefore undertook a comprehensive re-survey of primary and secondary triangulation throughout the three territories. This was related to the internationally determined geodetic chain along the 30th arc of meridian.

Three base lines were measured in Kenya by traditional methods, using invar tapes, standardized at the British National Physical Laboratory, suspended in catenary.

In the later stages of the work, however, extensive use has been made of Tellurometer micro-wave distance measuring equipment. A 350-mile Tellurometer traverse was made down the Tana River from Isiolo through country unsuited to triangulation. Portable 60-foot towers were used at approximately 15-mile intervals. A similar traverse was made from Isiolo northwards to the Ethiopian boundary triangulation. Tellurometers have also been used to check by direct measurement, derived lengths in the primary triangulation network.

Final co-ordinate values based on the 1960 value for the 30th arc of meridian have now been issued by the DOS for 121 triangulation and 40 traverse stations of the new Kenya primary network. The grid values are computed in metres on the Universal Traverse Mercator Projection using the Clarke 1880 spheroid.

(b) *Precise levelling*

A programme of precise levelling was begun in 1950 but was necessarily suspended between 1952 and 1958 through diversion of staff to emergency duties.

A total of 1,897 miles has now been double levelled and 5 main circuits have been closed within the limits prescribed by the International Union of Geodesy. The circuit closures obtained are as follows:

Circuit	*Perimeter (miles)*	*Circuit misclosure (feet)*	*Permissible error (feet)*
M	637	0.068	0.290
N	377	0.212	0.223
Q	541	0.012	0.267
F3	36	0.001	0.069
J2	100	0.048	0.115

The main line of levels from Mombasa to Lake Victoria has also been completed, but further work is necessary before final values can be obtained for benchmarks in the western sections of this line.

Difficulty has been encountered in closing two circuits in the Rift Valley region within international limits. These circuits, which are in an area of abrupt relief, are adversely affected by deformation of the potential surface due to geophysical mass anomalies. In co-operation with the overseas Geological Division of the British Department of Technical Co-operation a gravity survey was carried out in this area in 1962, to discover what element of the level misclosure is generated by variations in gravity. The results obtained improved the closure of the two circuits by 0.0389 ft. and 0.0661 ft. respectively.

The precise levelling programme has been carried out with instruments fitted with parallel plate micrometers, giving direct reading to 0.001 ft. on standardized invar staves.

Traverse have been run to determine the planimetric positions of benchmarks in order to facilitate their future identification.

(c) *Territorial boundary surveys*

Demarcation and survey have been carried out during the period covered by this report to define territorial boundaries of Kenya with Ethiopia, Somalia, Tanganyika, and Uganda.

The Kenya-Ethiopia Boundary Commission between 1951 and 1955 demarcated with intervisible permanent pillars the whole of the Kenya-Ethiopia boundary. The lines between the pillars were cleared and the pillars fixed by triangulation and traverse.

In 1956 and 1957 a 130-mile section of the Kenya-Tanganyika boundary along an arc of a great circle between the southern tip of Lake Jipe and Jassini on the coast was demarcated and surveyed as a joint undertaking by the survey departments of the two territories. Intervisible pillars at approximately 2-mile intervals were erected along the boundary and fixed in relation to ruling triangulation.

The Kenya-Somalia boundary was cleared and redemarcated with new boundary pillars in 1957 and 1958, and sections of the Kenya-Uganda boundary were demarcated in 1959 and 1960, again on a basis of interterritorial collaboration.

(d) *Gravity observations*

In 1955 a site was selected at the Survey of Kenya field headquarters in Nairobi, for a standard gravity station and "g" was measured by observers from the University of Wisconsin with Gulf pendulums. In March and April 1958 the station was reoccupied by an observer from the Department of Geodesy and Geophysics of Cambridge University, who used the Cambridge pendulums. The results obtained were as follows:

1955 Datum: Madison, Wisconsin: 980.3689 g
Nairobi: 977.5399 g

1958 Datum: Rome: 980.3637 g
Nairobi: 977.5402 g

(e) *Magnetic survey*

A magnetic survey of Kenya was carried out under the auspices of the UN Technical Assistance Administration in 1959. The Survey of Kenya co-ordinated permanent stations which were marked with angle brass in concrete.

Topographical mapping

The provision of comprehensive basic topographical

mapping to cover the whole Kenya was begun in 1949 and is now well advanced towards completion.

The work has been carried out in close co-operation by the Directorate of Overseas Surveys, the Royal Engineers, and the Survey of Kenya. Aerial photography has been provided by the Royal Air Force and civilian contractors engaged by the DOS.

In the more densely populated and economically significant parts of Kenya. basic mapping is at 1:50,000 scale with 50- or 100-ft. contours, while in the desert and semi-desert areas of the former Northern Province it is at 1:100,000 scale with 200-ft. form lines.

Initial plotting of the 1:50,000 series has been carried out by the DOS from vertical air photographs at 1:30,000 or 1:40,000 contact scale. Necessary ground control requirements have been met by DOS and Survey of Kenya field parties. Field collection of additional information (road classifications, place names, etc.) and the preparation of revision material for subsequent editions, has been dealt with by the Survey of Kenya. Latterly valuable use has been made of RAF photography at 1:50,000 contact scale for revision purposes. A uniform specification for 1:50,000 topographical mapping has now been agreed between the DOS and the national mapping organizations in Tanganyika, Uganda and Kenya. First editions are provided by the DOS in accordance with this specification and all subsequent editions are prepared and printed locally. To date 273 sheets of the 1:50,000 series have been published, some of them in up to nine editions. Of these, 100 are now available in contoured editions.

The basic mapping at 1:100,000 scale has been carried out from vertical air photographs at a contact scale of 1:80,000. Ground control, mainly by astronomical fixes, was carried out by a unit of the Royal Engineers as a basis for slotted template assemblies. Ninety-two sheets of this series have so far been published. Assistance is being given by the DOS in the production of further sheets in the Galole area of the Tana River. These are to be contoured at a 25-foot vertical interval for the purpose of the initial planning of a projected large scale irrigation scheme.

The printing of the 1:100,000 scale map series and all but the first editions of the 1:50,000 scale series, is carried out in Kenya on two Crabtree rotary double-demy size lithographic presses, placed at the disposal of the Survey of Kenya by the British War Office.

In addition to basic topographical mapping, much valuable derived mapping has been carried out during the period under review.

The Directorate of Military Surveys in 1954 began preparation of four special sheets at 1:250,000 scale, each $1\frac{1}{4} \times 1\frac{3}{4}$ degrees, on sheet lines chosen to make maximum use of the 1:50,000 mapping available at that time. Production of a new 1:250,000 series on standard sheet lines to cover in due course, the whole of Kenya, was begun in 1958. All four sheets of the 1954 series and 12 sheets of the 1958 series have so far been published.

A special 1:25,000 map of Mt. Kenya was produced in 1956 by the DOS, and the Survey of Kenya in 1961 prepared a 1:1,000,000 topographical map of the whole of Kenya in two sheets.

A statutory Standing Committee on Geographical Names has since 1948 undertaken the complex task of determining authentic names for inclusion on all published maps of Kenya.

Special purpose and township mapping

The Survey of Kenya has produced a variety of special purpose mapping ranging from rainfall and rainfall probability maps, at a scale of 1:2,000,000 to a "Hunting Map of Kenya" at 1:1,000,000 and a map of Nairobi Royal National Park at 1:30,000.

In addition maps of 14 townships in Kenya have been published at scales of 1:2,500 and 1:5,000 and also in 1962 a map of Nairobi at 1:20,000. Township mapping has mainly been carried out by photogrammetric methods.

The first edition of an *Atlas of Kenya* was published in 1960. The *Atlas* contains 47 maps illustrating physical, social and economic aspects of Kenya. A second revised edition is shortly to be published.

Cartographic and reproduction techniques

Reproduction material for both basic and derived mapping is prepared directly at publication scale, to enable the maximum benefit to be derived from photo-mechanical processes. This system eliminated registration difficulties since all drawings are on the same stable base material (either Astrafoil or Durafilm) and duplicates and "blues" are made by direct contact onto the same material. All line work is scribed. The necessary letter-press is either printed in register on both sides of sheets of 0.001″ Astrafoil on a Littlejohn proving press or is set photographically on stripper film on a Hohlux photo-typesetting machine. The printed sheets are mechanically waxed and require only cutting-strip and positioning on the master drawings. Conventional symbols are added in a similar manner. The completed composite drawings, one for each colour of the finished map, are photo-mechanically reversed ready for plate making. However, before this stage is reached a composite proof is made on a single sheet of Astrafoil, each component sheet being dyed in its appropriate colour. This proof enables a final check and proof corrections to be made before the actual machine plates are prepared.

Layer tints etc. are made in a similar manner. Masks on Astrafoil are first prepared by painting out the areas required with Astrafoil ink, photo-opaque or by using "peel-coat" Durafilm. The actual tint is then produced photo-mechanically by introducing an appropriate contact screen during the preparation of the Astrafoil reversals.

Cadastral surveys

Between 1902 and 1955 surveys for registration of title to land in Kenya were carried out solely on the system which requires the precise mathematical determination and beaconing of boundary corners and the derivation to rigorous standards of accuracy of the bearings and distances between them. The titles issued were of two main types, those which recognised existing rights of individual ownership at the coast and those which created individual rights of leasehold or freehold tenure over Crown land in

those parts of Kenya not reserved exclusively for occupation by the country's indigenous inhabitants.

Until 1955 land tenure in these latter areas was on a traditional basis in conformity with long established national and tribal customs which, except in rare cases, restricted long term individual ownership of specific portions of land. In 1955, however, an ordinance was introduced to make possible the registration of individual rights of ownership to portions of land, identified by general physical boundaries, in the areas reserved for the indigenous African population. This ordinance is not of universal application since in many areas, the majority of inhabitants do not wish their customary systems of land tenure to be changed. It has, however, been applied throughout the Central Region of Kenya, in the Meru and Embu districts of the Eastern Region and in many parts of the Rift Valley, Nyanza, and Western Regions. The ordinance provides for the rationalisation of existing land tenure, before the issue of titles either by consolidation of fragmented holdings, or the simplification of complex boundaries.

There are therefore at present in Kenya two systems of title survey, the one relying upon the rigorous determination of the positions of boundary beacons, the other dependent on the accurate determination and representation of physical boundaries. Legislation is shortly to be introduced, which will coalesce the two systems, making it possible wherever appropriate, to accept physically defined general boundaries as a basis for the issue of title.

In the period covered by this report, the Survey of Kenya extended and strengthened existing third and fourth order triangulation throughout the areas of alienated and unalienated Crown land. On the basis of this control, government surveyors, between 1950 and 1961, surveyed 17,900 portions of land, totalling 2,879,900 acres, mainly for initial alienation and the extension of existing leases. During the same period, private licensed surveyors carried out surveys of 17,400 portions of land, totalling 2,778,200 acres, mainly comprising private subdivisions of alienated land. All these surveys were carried out by traditional ground survey methods.

All records of work carried out by Government and by private surveyors, were examined and approved by the Survey of Kenya before transactions based on the surveys were registered, thus ensuring the maintenance of uniformly high standards of accuracy and preventing errors.

Between 1955 and 1962, second, third, and fourth order triangulation extension and breakdown were carried for the first time into the sections of the African lands (or as they are now termed, the Special Areas) where farm planning and the issue of individual titles was envisaged.

Throughout the Central Region and in the Meru and Embu Districts of Eastern Region, issue of title to individual properties in the Special Areas has been preceded by the consolidation of fragmented holdings. To enable the Administration effectively to allocate the consolidated portions, topographical base maps at 1:2,500 scale have been provided by photogrammetric methods. In conjunction with land consolidation, hitherto unoccupied land has been opened to settlement, notably in Meru District, and 1:2,500 base maps have been provided for these areas also.

Base mapping has also been supplied at 1:2,500 scale for extensive areas in the Rift Valley region where either the allocation of individual holdings in already populated areas, or the settlement of hitherto unpopulated land, has taken place.

Il all, topographical base mapping for over 2 millions acres in the Special Areas, has been produced since 1955.

The air photography for this mapping was taken at 1:25,000 contact scale, machine plotting carried out at 1:5,000 scale and mapping produced by double enlargement of the machine plots.

In Western and Nyanza regions rationalization of existing property boundaries has been carried out by working directly on air photographs at 1:12,500 scale. Photography covering over 670,000 acres has been taken for this purpose.

The demarcated boundaries of all properties defined in the process of land consolidation, adjudication of rights, or new settlement, are marked on the base maps by administrative officers and their staff, using simple survey methods to augment straight-forward map reading. The resulting pattern of boundaries is then produced in the form of a provisional land registry index map, to illustrate the parcels for which titles have been issued. The representation of the property boundaries is, however, at this stage by no means exact and before they can be precisely mapped, it is necessary to wait until hedges along the boundaries have become sufficiently advanced to be clearly visible from the air. When this situation exists, further air photography is taken at 1:12,500 contact scale, for direct plotting at 1:2,500 to illustrate the final property boundaries. Any boundaries which are not clearly visible to the machine operator, are investigated and fixed in the field. Thereafter, final land registry maps are prepared and substituted for the provisional ones previously held by the Registry.

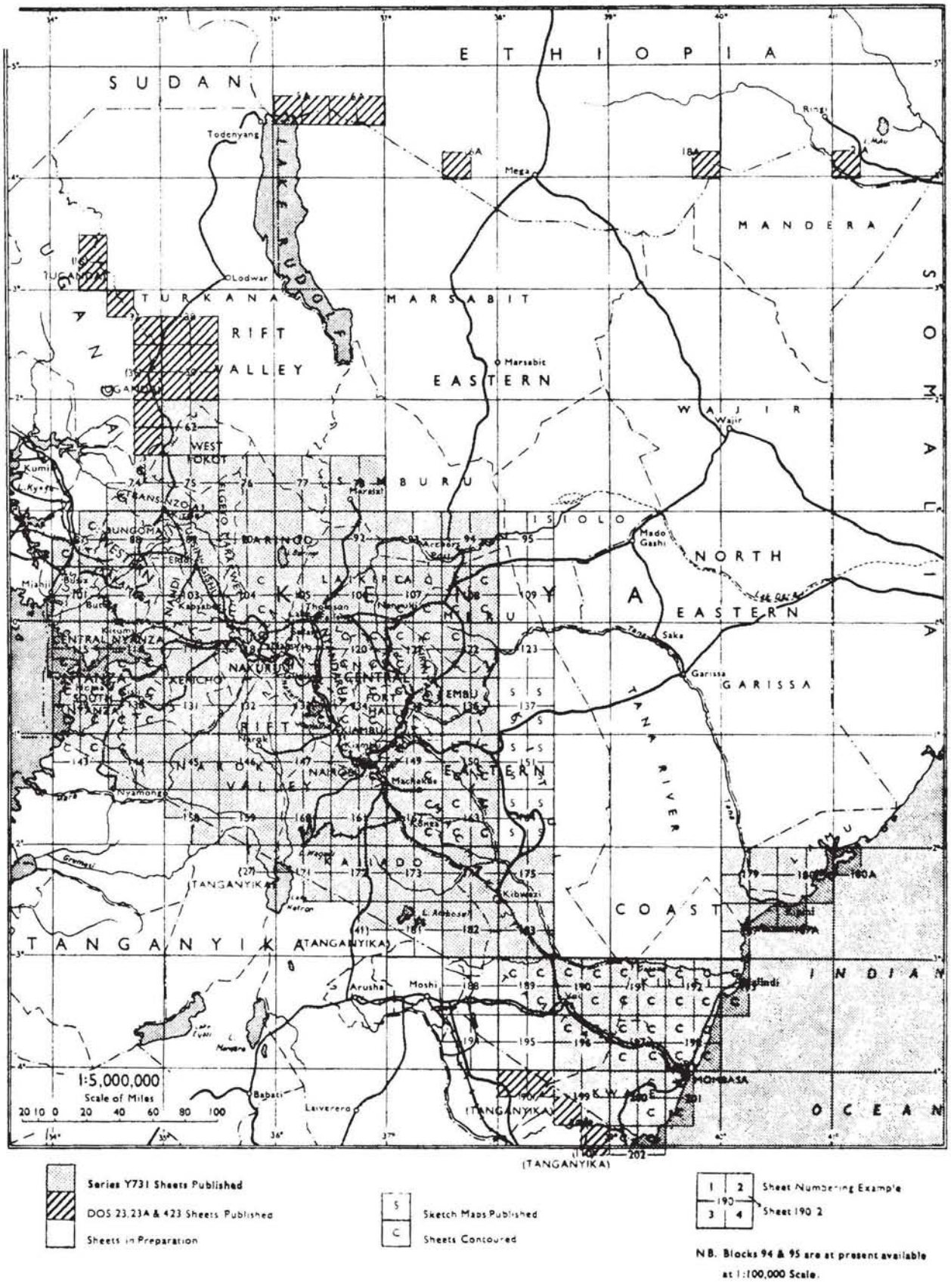
Final land registry index maps illustrating the boundaries of individual properties, have so far been produced for an area of 270,000 acres.

Mutations following production of final land registry index maps are dealt with by the Survey of Kenya by ground methods.

Scheduled areas settlement schemes

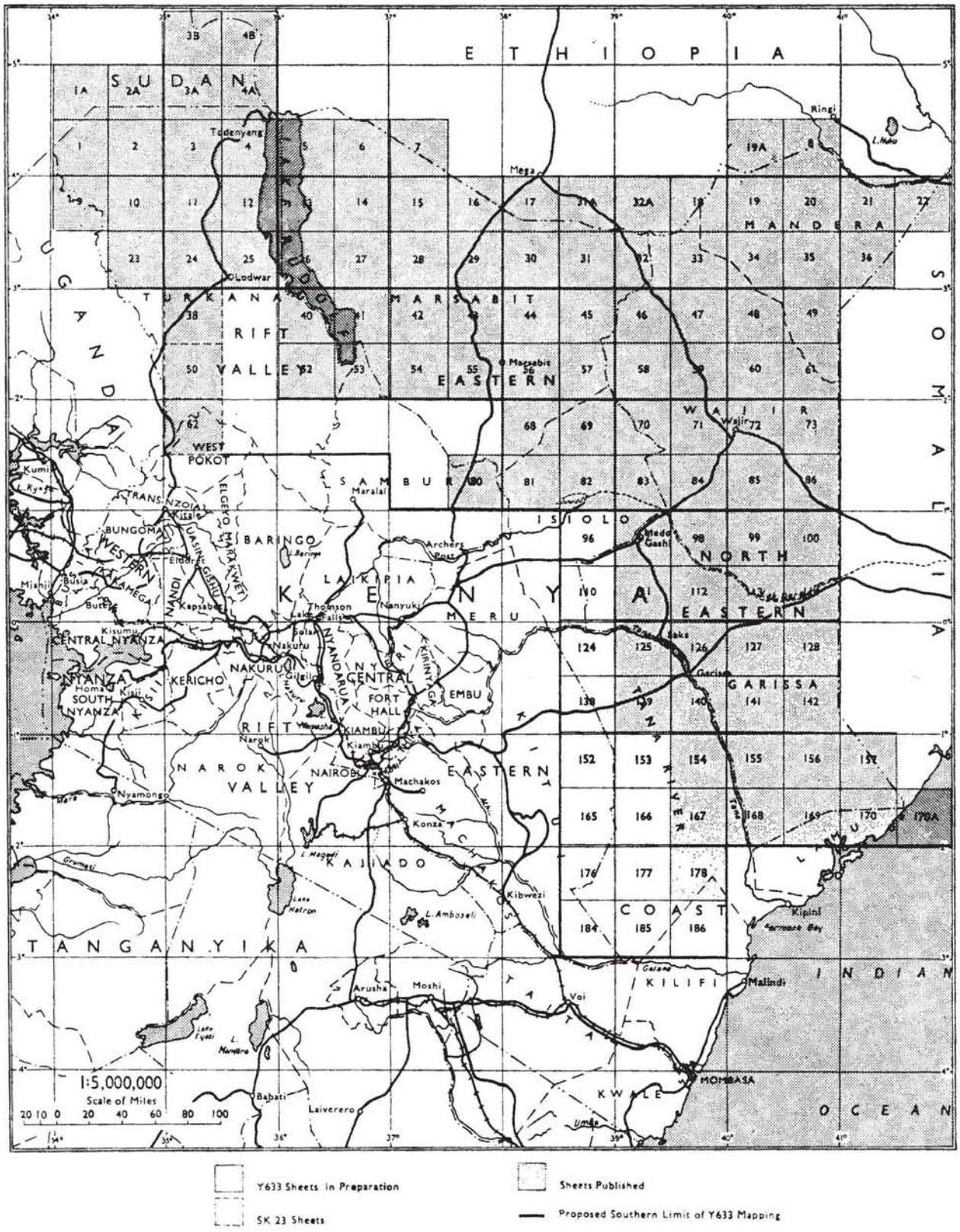
In 1962 it was decided by the Kenya Government that alienated Crown land and freehold properties in areas of high farming potential outside the Special Areas should be purchased for re-allocation of African farmers. The properties purchased are generally of considerable size, ranging from several hundred to several thousand acres in extent. The average size of the portions allocated to the new settlers on the other hand is only 15 acres, ranging between an upper limit of about 200 acres and a lower limit of about 5 acres. Careful planning of the new holdings is therefore necessary to provide for soil conservation and to ensure that the plots allocated have an adequate economic potential. To enable officers of the Agricultural Department in consultation with the Planning Adviser to proceed with the systematic layout of the new plots, it has therefore been necessary for the Survey of Kenya to provide topographical base maps for the areas included in the settlement schemes. Initially, some of

KENYA 1:50,000 TOPOGRAPHICAL MAPS



Kenya : index map : 1:50,000 topographical maps

KENYA 1:100,000 TOPOGRAPHICAL MAPS (Y633)



Kenya: index map: 1:100,000 topographical maps

Kenya: index map: 1:250,000 topographical maps

these were provided photogrammetrically from existing 1:25,000 and 1:20,000 scale air photographs at a 1:5,000 mapping scale. At the insistence of the Agricultural Department, all mapping for the schemes is now being carried out at 1:2,500 scale with 10-foot contours, and intermediate 5-foot form lines in areas of average relief and 20-foot contours, in areas of sharp relief. Air photography at 1:12,500 contact scale is specially flown for the purpose of this mapping. Between the beginning of 1961 and the time of writing, 184,000 acres have been mapped in this way for the settlement scheme. It is envisaged that the scheme when completed, will embrace 1 million acres for the majority of which the Survey of Kenya will provide necessary topographical base maps at 1:2,500 scale.

Title for the holdings allocated to the new settlers, will be issued on a basis of physically demarcated general boundaries. The necessary surveys of these boundaries for title purposes, has now been begun and is to be dealt with by a combination of ground survey and photogrammetric methods.

Cadastral survey records

Basic cadastral records in the areas of Kenya surveyed for title purposes by rigorous ground methods, consist of the surveyor's original field notes, computations and plan which, following examination and approval, are retained by the Survey of Kenya.

A lithographed cadastral index series at a scale of 1:62,500, prepared from these original records, has progressively been converted to a new series at 1:50,000 scale. In order to ensure that the information shown on these sheets is up to date, they are now being prepared not in lithographed form but on durafilm from which dyeline prints incorporating all recent revisions, can be made.

The 1:50,000 cadastral series on sheet lines corresponding to the 1:50,000 topographical series will henceforth be the basis for registration of title in all cases outside the Special Areas, where general boundaries can be recognised. This will include all properties in the scheduled areas settlements schemes referred to above. Cadastral registration sheets at 1:10,000 scale and 1:2,500 scale devolving from the main 1:50,000 series, will be prepared in all cases where the smallness of properties makes this desirable.

An overall 1:250,000 scale cadastral index series in four lithographed sheets illustrating the boundaries of private properties outside the Special Areas in Central Kenya, has been in valuable use since it was first prepared in 1949.

Land registry index maps for titles to land in the Special Areas of Kenya are prepared on astrafoil at 1:2,500 scale on sheet lines appropriate to the various registry units. Dyeline prints from the master astrafoils are supplied to the land registries in the Special Areas, incorporating mutations as they occur.

Photogrammetry

The Survey of Kenya now undertakes all photogrammetric mapping in Kenya for purposes other than the basic topographical map series at 1:50,000 and 1:100,000 scales.

Air photography is obtained with a Wild R.C.8 camera mounted in a de Havilland Heron aircraft of the East African Directorate of Civil Aviation.

Diapositives are prepared by Logetronic printer and aerial triangulation carried out on a Wild A.7 Autograph.

Large-scale topographical base maps are prepared mainly on 4 Kelsh and 2 Nistri anaglyph machines and a Wild B.8 Autograph, while mapping for cadastral boundary determination is carried out on 4 Wild A.8 Autographs and a Calileo Stereo-Simplex 3.

Adjustment of aerial triangulation has been carried out when appropriate by Jerie Analogue computer.

Valuable use has been made of P.U.G. I point transfer device.

Training

Since 1955 training of personnel in all aspects of survey has been carried out at the Survey of Kenya Training School. Basic courses of instruction have been provided for locally engaged surveyors on first appointement, and more advanced courses for surveyors of this category, after they have gained practical experience. In conjunction with the courses of training, a system of occupational tests has been devised to enable the progress of surveyors, cartographers, lithographers and photogrammetric assistants to be assessed, and their advancement to higher grades decided upon. The tests are held once a year as also are professional examinations at a more advanced level, set by the Land Surveyors' Board of Kenya, the controlling body for the surveying profession in Kenya. The Survey of Kenya does not, however, undertake to provide specific training at the professional level, but through arrangements with the Kenya Government has enabled certain suitable candidates to attend courses leading to professional courses at academic institutions both in Kenya and overseas.

STANDARD FREQUENCY TRANSMISSIONS IN KENYA[1]

To help in the establishment of a world-wide navigation aid the Royal College, Nairobi is setting up a V.L.F. monitoring station in collaboration with the Royal Aircraft Establishment, Farnborough, England. This will be one of six similar stations of the system being operated in different parts of the world; the other five being located in Ottawa, Rome, Idris, Singapore and Farnborough itself.

The main purpose of the Nairobi station will be to monitor V.L.F. transmissions from G. B. R. Rugby, N. A. A. Cutler and N. P. M. Hawaii. Propagation times of transmissions from these sources will be measured by monitoring phase changes.

As a secondary aim the R.C.N. are planning to transmit

[1] The original text of this paper, submitted by Kenya, appeared as document E/CN.14/CART/7.

a system of standard time signals in Kenya for a trial period of about three years, approximately, from the latter part of 1963. It is not yet decided whether these time signals will be transmitted continuously throughout every twenty-four hours or for limited periods only during the early morning, day, afternoon and evening. The final decision in this regard will depend largely on the usefulness of the signals to geodesists and scientists in Africa and elsewhere, within the range of the transmitters which are to be used.

Signals will be controlled by frequency standards provided by the R.A.E. These are a Sulzer quartz crystal oscillator which is accurate to a few parts in 10^9 per week and/or a Varian Rubidium frequency standard accurate to about a few parts in 10^{10} per week. The R.C.N. would be prepared to publish time corrections for its transmissions based on propagation information recorded from transmitted time signals from Rugby.

Delegates interested in standard frequency transmissions from Kenya are invited to contact the Royal College.

THE HISTORY OF GEOLOGICAL MAPPING IN KENYA[1]

Report by R. G. Doddson, Geologist, Mines and Geological Department Kenya

Abstract

The paper gives a brief outline of the history of geological mapping in Kenya. Early work was mainly directed at investigation of areas of economic importance. Later, in the post-war period, a programme of regional geological survey was started, the object being systematic mapping of Kenya by quarter-degree sheet areas. A short description is given of the methods of geological mapping and topographical map construction used by geologists of the Kenya Geological Survey.

Introduction

The classic sequence of geological mapping of a country or a regional unit is the progressive enlargement of the scale and scope of geological maps. Thus, the earliest geological maps may be on scales as small as 1:500,000 and will only show the boundaries of the principal geological formations. The topographical features shown in such a map will be correspondingly bare of detail. Subsequent work is directed at mapping on an increasingly large scale to allow the recording of geological and topographical data in greater detail. The procedure briefly outlined above is purely hypothetical and in most countries geological work is directed at fulfilling certain requirements such as the investigation of economic or hydrological possibilities of particular areas.

In Kenya the earliest geological mapping was largely governed by a need for investigation of known or suspected gold bearing areas. Report No. 1 of the Geological Survey of Kenya, "The Loldaika–Ngare Ndare Area", printed in 1933, dealt briefly with a supposed discovery of gold and radium north of the Loldaika hills. The report did not include an accompanying geological map. Early reports which followed were mainly concerned with the gold bearing areas of Nyanza. After the last war the regional geological survey of Kenya was begun, the programme planned being the systematic mapping of Kenya by quarter-degree sheet areas. Priority in choice of areas was governed by their accessibility and reported mineralization. By 1950 an increase of staff accelerated the programme and today approximately two-thirds of Kenya has been geologically mapped in reconnaissance style. Initially the maps depicting the geology of quarter-degree areas were printed on a 1:125,000 scale. In late 1962 it was realized, however, that in many parts of the Northern Province where detailed surface geology is lacking, or extensive tracts are covered by lava sheets or superficial deposits, four such quarter-degree sheet areas could profitably be combined and be produced on maps of 1:200,000 scale.

Methods of geological mapping

Ideally the geologist goes out in to the field equipped with a coverage of air photographs and a set of detailed topographic maps, preferably of various scales to suit the complexity of the local geology. Actually a considerable proportion of the maps produced by the Kenya Geological Survey have been topographically mapped by geologists. In the areas not covered by air photographs, the geologist has to resort to construction of maps by plane-table and in some cases theodolite traverses, aided by such simple, but in most instances effective, instruments as the Indian clinometer and cyclometer, or measuring wheel.

The availability of air photographs has revolutionized both geological mapping and the construction of topographical maps. The method of map construction with the aid of air photographs used in Kenya for use as a base for a geological map is as follows: prior to departure for the field, the geologist draws tracings of runs of photographs, preparing each of the photographs by transferring centre points from contiguous photographs, together with an appropriate number of pass-points common to the overlap areas of adjacent photographs. After selecting a suitable scale, normally based on two photographs centre points, the scale is standardized for that run by "raying in" pass-points on successive photographs to pass-points initially located. This simplified procedure obviates the cutting of slotted templates. The accuracy of the final product is dependent on the diligence and care taken by the individual. To allow accurate reduction of topographic and geological data on the tracings to a predetermined scale, it is essential to fix two points on each of the strips of country covered by the air photograph runs. Form lines are fixed from corrected barometric spot heights, and drawn with the aid of a Kalk stereo plotter.

[1] The original text of this paper, submitted by Kenya, appeared as document E/CN.14/CART/37.

Work in the field consists mainly of recording all geological data on either the tracings or a completed map, the amount of detail included depending on the scale of the map and the complexity of the local geology. After the completion of fieldwork, each of the tracings is photographed and printed on a predetermined scale, the adjustment calculated from the relationship between fixed points established in the field and their located positions on the tracings. The maps are initially drawn on a scale one third larger than that of the final printed map.

Geological maps are normally printed in colour to simplify the illustration of different geological units, but maps of low complexity are sometimes printed in black and white, the geology illustrated by the use of symbols, numbers, or various types of shading.

The role of topographical maps and air photographs in geological mapping

While the field geologist is not helpless without accurate topographical maps and air photographs, their importance to him cannot be overemphasized. Detail maps frequently exhibit features reflecting important structural, lithological and geomorphological data. Thus, fault scarps may be identified, differential weathering of composite rock formations recognized, and in some cases contrasting land forms of different formations are manifested in the topography. Remnant fossil land-surfaces can often be identified by statistical analysis of surface altitudes in a grid pattern.

The value of air photographs as an aid to geological mapping is dependent first on the quality of the photographic prints and, secondly, on the type of geology covered by the photographs. For example, in parts of Northern Kenya where nearly horizontal strata form a featureless topography, scant information can be deduced from air photographs. By contrast, in eroded areas where metamorphic rocks are well exposed, or in the volcanic regions of the Rift Valley of Kenya, abundant detail can be obtained from a study of air photographs, preferably with the aid of a stereoscope.

Conclusion

As an initial programme of regional survey in Kenya nears completion, geological mapping in greater detail of selected areas will be possible. The areas selected for detailed mapping will be chosen primarily for their economic potential. It is hoped that with the passage of time geologists of the Kenya Geological Survey will enjoy the luxury of the use of even more detailed, large scale topographic maps produced by topographic surveyors!

TEN YEARS' ACHIEVEMENT OF THE LIBERIAN CARTOGRAPHIC SERVICE[1]

In November 1961, the Liberian Cartographic Service (LCS) celebrated the 10th anniversary of its foundation.[2] The Service was established by the Liberian Government as a joint venture on 5 November 1951 to provide a Liberian staffed organization to supply prerequisite data for all economic development projects with emphasis on natural resources investigation, exploration and exploitation as well as construction of access roads, housing and utilities for these projects. It was originally staffed by the United States Coast and Geodetic Survey officers and a Liberian who later qualified at the International Training Centre for Aerial Surveys, Delft, Holland, and took over as its first Liberian Director in July 1955 by appointment of the President of Liberia, and who has been in charge until the present with the assistance of nine foreign trained and nine locally trained Liberian technicians, engineers, photogrammetrists, geodesists, aerial photographers, photolithographic pressmen, an aircraft pilot, laboratory technicians and hydrographers. The same number of technicians had been previously trained by the service for work in kindred organizations, where they are now serving.

While satisfying the intent of a Liberian staffed mapping institute, this Service has produced the following results for the prescribed purpose of providing data for natural resources investigation and exploration:

Determination of near-first-order astronomic positions and barometric elevations for the shoran controlled near vertical aerial photography covering eighty-seven per cent of Liberia at scale 1:40,000 and simultaneous magnetometer-Scintillometer survey of probable deposits both of which were made with participation and supervision of this service. Extending mapping from photographic coverage to ninety-five per cent using existing US Army Map Service aerial photography.

First-order vertical control on Monrovia-Kakata road for highway construction and future topographic mapping as data for economic development.

Establishment of instrument standardization references. Near-first-order triangulation and levelling of Monrovia for future topographic mapping as data for economic development. Compilation of planimetric map of Liberia in ten sheets from 1:20,000 controlled mosaics of the Aero Service Corporation contract and the arranging for printing in four colours of 500 sets of 10 sheets at 1:125,000 5,000 sets of two sheets at scale 1:500,000 and 10,000 sheets at scale 1:1,000,000 drawn on Hotine's rectified skew orthomorphic (polyconic) projection.

Aiding Mr. Griff Davies with personnel and facilities in setting up the Audio Visual Centre as well as direct exe-

[1] The original text of this paper, submitted by Liberia, appeared as document E/CN.14/CART/81 and Add.1, under the title "Preparation and reproduction of maps". For better integration into the present report, the original paper has been divided into: "Ten years' achievement of the Liberian Cartographic Service", "Preparation and reproduction of maps" (see agenda item 15) and "Proposed reorganization of the Liberian Cartographic Service" (see agenda item 7).

[2] "Ten years' achievement of the Liberian Cartographic Service" by J. Laurence F. Sawyerr. Copies available at the Liberian Bureau of Natural Resources & Surveys. Copies also in the minutes of the Tenth Congress of the Fédération internationale des géomètres.

cution of visual aids for all economic development projects prior to the final establishment of the visual aids centre.

Hydrographic surveying and mapping of the proposed Cape Palmas Harbour of Monrovia, Lofa and Farmington and topographic mapping of Harper and Monrovia.

Aerial photography by the staff of this service using LCS Cessna 170 aircraft and LCS Fairchild cartographic camera of 15,000 exposures of areas of economic development, to supply maps on economic development projects with our 170 A aircraft. These areas included Bomi Hills, Bassa Harbour, LAMCO railroads, Monrovia and parts of Careysburg, covering almost 12,000 square miles.

Tidal observations of Monrovia, Harper, Farmington and Lofa.

Compiled, printed and distributed 51,000 maps of sundry scales and purposes from over 400 originals.

Made 12,700,000 copies of 10,000 originals of miscellaneous records for distribution, by off-set printing and photography performed by LCS staff with LCS equipment.

Distribution of the above listed data extended to every branch of economic development project in Liberia.

The Liberian Cartographic Service, however, had to evacuate its quarters early in 1959 and is still without a proper housing, resulting in fast depreciation of delicate instruments and a slowing down of operations under makeshift conditions.

All that is needed now for high standard operation is adequate housing and improved instruments as outlined in the expert report[3] of Professor W. Schermerhorn from the International Training Centre for Aerial Survey at Delft. In this part of his report entitled "Proposed reorganization of the cartographic service of Liberia" Professor Schermerhorn considers it necessary to provide Liberia with a Cartographic Service which, after a period of 5 years, will be able to carry out the production of all maps required by the various services of the country without substantial assistance from abroad. This includes not only topographic maps and different kinds of maps for forestry, geology and soils, but also maps for census, social services and general administration.

[3] "Reorganization of the Liberian Cartographic Service" by Prof. D. Ir. W. Schermerhorn. Copies available at the International Training Center for Aerial Survey and at the Bureau of Natural Resources and Surveys of Liberia. A pertinent excerpt is reproduced in "Reorganisation of the Liberian Cartographic Service". (See agenda item 7.)

CARTOGRAPHY IN MOROCCO[1]

By A. Hakam, Head of Geographical Service

Morocco is happy to take part in this Regional Cartographic Conference for Africa organized under the auspices of the United Nations.

In view of its geographical situation and greatly varied relief, Morocco offers an extremely interesting field to the cartographer. About 52 per cent of its 12 million inhabitants are under the age of nineteen years; Morocco is therefore a young country whose endeavours are being directed under the wise guidance of its rulers towards the country's general development.

The transfer to the Moroccan Government of the cartographical work hitherto carried out by the French National Geographical Institute has led to the establishment of the new Geographical Service of Morocco.

Morocco is now one of the better-equipped countries as regards cartography. With the exception of an East-West strip across the extreme south, the geodetic network has been completed. The entire territory is covered by a system of first order levelling links, checked by gravimetric observations. The aerial photographic coverage has been completed and revised every year in the more active regions.

The whole of Morocco has been covered by a map on the scale 1:100,000 or 1:200,000, called a reconnaissance map, on which, in the important economic regions, a more detailed map has been superposed, established according to international standards (conformal projection) on the scale 1:50,000 and 1:100,000 (regular). These latter maps cover about one-third of the surface of Morocco.

The preparation of regular maps on the scale of 1:50,000 has been accelerated. But it is a long-term task, and for certain regions with a limited economy regular maps on the scale 1:100,000 are being considered, as they can be carried out in a more reasonable time. For certain regions of rapid economic development, and particularly for the large irrigation areas, larger-scale maps at 1:20,000 are being planned.

On the basis of all these considerations, a general cartographic programme has been drawn up for Morocco, ranging from 1:20,000 to 1:100,000, according to the stage of economic development of the regions. All these new maps have been made in accordance with the international standards for sheet lines.

An ambitious programme of this kind requires modern facilities and the Moroccan Government is making great efforts to modernise the country's equipment in printing machinery, counter-proof presses, photomechanical reproduction benches, first and second order photogrammetric apparatus, study and research laboratories, etc.

Efforts are also being made to train technical personnel. To alleviate the shortage of technicians, large numbers of engineering students are being sent to the French National Geographical Institute in Paris and the Polytechnic School in Lausanne, where they receive an excellent training in the various branches of topography, photogrammetry

[1] The original text of this paper, submitted by Morocco, under the title "La Cartographie au Maroc" appeared in French as document E/CN.14/CART/54.

and cartography, and thus we shall be adequately prepared for the future. Some have studied in factories of international repute and have acquired a grounding in the manipulation of high precision apparatus.

The Moroccan administrative authorities are well aware of the value of cartographic documents and requests for new work far exceed the possibilities of the Geographical Service. It is therefore planned to set up a National Committee for Cartographical Work, to co-ordinate work in this subject in agreement with the users, and to draw up a rational programme.

Finally, it is worth while mentioning the work now in progress for the publication of a general Atlas of Morocco and the establishment of a national library of photographs showing the complete photographic coverage of the territory.

NOTE ON CARTOGRAPHIC WORK IN SENEGAL[1]

Mapping and topographical charting in Senegal may be divided into two broad categories:

The first is the *topographical map*, the scales of which vary from 1:50,000 to 1:7,500,000. Generally speaking it is the map common to West Africa with certain variations in the stages of progress, prints and issues. It supplies the basic cartographic data for the preparation, organization and execution of studies. So far it has been compiled by the former Service géographique which is now an annex of the Institut géographique national de France.

The second is the large-scale topographical map 1:1,000 to 1:5,000. In many cases, this map, combined with aerial photography, forms the practical working document when the stage of localization and execution of the projects is reached. In certain cases it is compiled by the Topographical Section of the Ministry of Public Works. In many other cases, however, the assistance of private enterprise has to be sought, in which case the section is responsible only for ground control.

The variations in each of these types will now be briefly outlined.

A. Types of maps and plans

I

1. *General maps*

(i) Map on the 1:50,000 scale covering one-fifth of the territory of the three regions forming economic poles of attraction.

(ii) Map on the 1:100,000 scale covering the maritime coastal region from Saint-Louis to the Gambian frontier.

(iii) Map on the 1:200,000 scale covering the whole Territory.

(iv) The general map of West Africa on the 1:500,000 scale.

(v) Map on the 1:5,000,000 and 1:7,500,000 scales.

2. *Local maps*

Because of its privileged geographical situation the region of Cape Verde is the main pole of urban and industrial attraction in Senegal, a fact which has led to the compilation of several maps in this locality (1:50,000, 1:20,000, 1:10,000 and 1:7,500).

3. *Special maps*

(i) Administrative and touristic map on the 1:500,000 scale.

(ii) Gravimetric map on the 1:1,000,000 scale entitled "Sénégal - Falémé"

(iii) Magnetic map which is being checked by the redetermination of one point per km^2.

(*a*) The Administrative and Touristic Map on the 1:500,000 scale includes the boundaries of the regions and districts overprinted on the general map on the scale 1:500,000. The whole road network, the forest preserves and touristic sites are represented.

(*b*) Gravimetric Map—this map compiled on the scale 1:1,000,000 covers Senegal and a part of Mali. It is entitled Sénégal - Falémé. Its compilation was made possible by the work of the M'Bour centre géophysique (Geographical Centre) and the oil prospecting companies. It has been completed.

(*c*) Magnetic Map—the magnetic map forms part of the general magnetic map of West Africa. In so far as Senegal is concerned, the base magnetic network has been completed. This network, however, is large (1 pt—from D.H and Z per degree squared). The checking will consist of a redetermination, which will be carried out at a density of 1 point every 1,000 metres.

(*d*) Mining and Geological Map—explanatory geological map on the scale 1:2,000,000; start of the map on the 1:500,000 scale using existing documents; geological map of Eastern Senegal based on new ground work (1:500,000) and work being performed by a UN mission.

On the whole, therefore, no suitable geological map.

II

1. Large-scale plans

(i) *For the allocation of plots of land*

There is a fairly large number of them (halting places in the interior). There are two main criticisms.

They are vey old and it has not been possible to bring them up to date regularly since at the time they were compiled there was a scarcity of staff and funds and technical means were limited. In addition, in certain cases the accelerated rate of growth of some halting places has caused a gap as regards the topography represented, the homogeneity and the degree of precision of the peripheral

[1] The original text of this paper, submitted by Senegal, under the title "Note sur l'activité cartographique au Sénégal" appeared in French as document E/CN.14/CART/57.

sectors, the extension having been effected without adjustment to the central parts.

They are quantitatively incomplete from the technical point of view, due allowance being made for the present planning needs of towns and halting places, most of which are only in the very early stages of allotment.

These two reasons are explained by the fact that their original purpose, namely to be used as allotment plans, the first framework of a future cadastre, was abandoned. As this goal was not attained the plans were laid aside; although it was desired to keep them for the purpose of land allotment they are subsequently used as topographical plans in the broad sense.

(ii) *Topographical survey plans*

They include all the planimetric details and elevation dots on metric contours. These plans are more and more in request for such different purposes as road works, water supply, urbanization, public works, surveys for the extension of land lots and agricultural development.

There are at present, unfortunately, only four of these maps and they cover only the large towns. This is a big gap which must be filled in the near future.

B. TOPOGRAPHICAL SURVEY METHODS

Topographical maps—generally speaking these maps were produced by the Service géographique français. The methods employed have been known by the publications issued by the Institut national géographique français.

Plans—they have been produced by the Topographical Service of the Ministry of Public Works. Although the accuracy of these maps is not of a very high degree, it is adequate in relation to the scale employed. Moreover, the uses for which these maps are required and the time allowed for their reparation which is frequently very short results in the use of makeshift measures and of information already available.

1. Plans of secondary halting places intended for in extension of the land allocation schemes are often produced by the following methods:

Aerial photogrammetry on the 1:6,000 scale;
Rectification and enlargement of roofs;
Tracing and interpretation (planimetric);
Polygonation on the ground;
Tacheometer levelling for the scribing of contour lines.

This is a relatively inexpensive mapping method, taking into consideration the rapidity of its execution and the readily adaptable to the continually increasing inventory riquirements of building land development. Until the present, halting places in Senegal have been developed without master plans, a state of affairs which is being taken in hand by the Commissariat à l'Urbanisme du Sénégal (Senegal Town Planning Board). This fact should be clearly borne in mind when graphic rectification is replaced by the more rapid photographic rectification.

2. *Project plans* (scale 1:2,000) for location of clearance areas, town planning, ground survey for development of building plots. In view of the uses to which they are put, plans of this type need to be of a high degree of accuracy. therefore the mosaic obtained from the enlargement of the large scale (1:6,000) photographs may be put to rapid and advantageous use.

3. *Road reconnaissance plans*—aerial photographic cover along the proposed direction of a road provides a strip of large scale photographs. After rapid scrutiny and interpretation of the photographs under a stereoscope the photographs are assembled into a mosaic of 25 to 30 km stretches. It is then possible to study variations of the road planned without the need for arduous field work by noting prominent topographical details by interpretation.

4. *Survey plans* (drainage, distribution, public works). These plans are produced by the *Entreprise*.

Methods used are summarized below:

Aerial photographic cover on a scale of 1:3,000 or 1:5,000;

Precise stereopreparation providing at least 8 check points per pair;

First order plotting by instruments. In densely built-up areas the vertical plotting is shown by elevation dots. In other cases contour lines are marked.

5. *Inventory plans*—carried out on the ground by:

Polygonation;

Detailed surveys by theodolite or tacheometer.

This method is only used for surveys of urban districts or small townships in the interior. This method is slow and somewhat inaccurate for large areas.

REPORT ON CARTOGRAPHIC ACTIVITIES IN SIERRA LEONE[1]

Report by the Director, Surveys and Land Department

The Surveys and Lands Division is part of the Ministry of Lands, Mines and Labour and as such is charged with the mapping and land administration of Sierra Leone. The Government is well aware of the need for good mapping to assist in the compilation of basic information and to ensure that economic and social development is adequately co-ordinated. Since Independence in April 1961 the Sierra Leone Government has become increasingly aware of the many cartographic problems and the desirability of partaking in Conference of this nature to ensure that her small but vital Surveys and Lands Division is more adequately prepared to assist with the future development of Sierra Leone. It is with this in mind that Sierra Leone

[1] The original text of this paper, submitted by Sierra Leone, appeared as document E/CN.14/CART/53.

has recently requested to become a member of the International Union of Geodesy and Geophysics.

Topographic surveying

Before the topographical survey of Sierra Leone started in September 1925 the Freetown Peninsula was triangulated by Captain Pearson, R.E., in 1902. This resulted in a series of 3 sheets at 1:63,360 with contours at 100-feet interval covering 270 square miles approximately. The rest of the country, 27,600 square miles approximately, was covered by 9 sheets at 1:250,000 and embodied the work of the Anglo-French Boundary Commission of 1895-1896 and that of the Anglo-Liberia Boundary Commission of 1903 and 1913-1914. Various sketches and route reports executed by Military and Administrative officers also existed. One such interesting map was made of 6 sheets of the North-west at 1:125,000 by Sir James Maxwell, K.B.E., C.M.G.

The cartographic mapping being so scant and unreliable it was agreed in September 1925 to start a new topographical mapping programme. The cost was limited to £60,000 and the scheme planned to take 4 years to provide a 1:62,500 series with contours at a vertical interval of 50 feet. The area covered was to be 30,000 square miles which gave the cost per sheet at £500 approximately. The horizontal framework was to be fixed by astronomy and wireless and the vertical framework by use of dumpy levels. Four European officers were available as well as a nucleus of Africans from the Gold Coast Surveys Department. In order to train Sierra Leoneans it was decided to set up a Survey School with 10 trainees.

The country is flat and low-lying in the South and West and broken and elevated in the North and East. River drainage is from N.E. to S.W. with heavy rainfall from July to September. Heights of over 6,000 feet exist in the N.E. which are suitable for triangulation and whilst in the low-lying areas there are isolated hills this area is not easy for triangulation. Communication in 1925 was by the railway and limited by lack of roads. Consequently, carrier transport was the only form of communication available over the greater part of the country.

The field party had its headquarters at Magburaka in the centre of the country for most of the period. By June 1926 they had fixed 31 points by astronomical observations and using wireless signal; completed 475 miles of topographical levelling and surveyed in detail 6 sheets covering 1,800 square miles.

The horizontal framework consisted of 123 points determined by astronomical and wireless methods. These points were approximately a quarter of a degree of arc (17 miles) apart so that they fell at sheet corners. The time and money available did not permit anything more ambitious. Twenty-one observations only for latitude were made so that compass traverses for detail could be adjusted. The 123 points were observed over a 5-year observing period. Since the season was from December to March the method of observing for latitude was varied to suit the prevailing climatic conditions. For both time and latitude observations six pairs of stars at least were taken using 5″ micrometer theodolites. The evening time signal from Bordeaux was invariably used and no difficulty was experienced in wireless reception.

Heights were referred to Mean Sea-level at Freetown as determined by H.M.S. *Endeavour* in 1924. It was decided on grounds of economy to accept the 330 miles of levelling carried out on the railway survey. Lines of levels were executed entirely by the African staff and followed main paths where possible. Connecting lines were of about 30 miles by aneroid barometer fairly reliable secondary levels. Distances between staff and level were normally 150 feet and readings taken to one-thousandth of a foot. Some 1,670 miles of such levelling were carried out.

The standard field sheets were 30′ of latitude and 30′ of longitude and were drawing paper mounted on zinc sheets. The framework points were plotted at headquarters. The funds available permitted 450 miles of traverse per sheet or about 1½ miles of traverse per square mile of country. About 50 miles of this were carried out by compass and steel band and the remainder by compass and a 310-feet rope. The steel band traverses were started and closed on a framework point.

The field party completed a field sheet record book showing by diagrams the position and type of each traverse; a brief history of the survey; general description of the country; and description and sketch of each framework point; description and accepted height of each bench-mark and a list of secondary barometer values. Each river and village encountered by the surveyor was given a number and recorded in a village and river book. The surveyor recorded the name of the village; the accepted spelling; the number of houses; the name of the headman; the chiefdom; market days; churches; mosques; missions; water-supply and any item of interest. In the case of a river the surveyor recorded its name, accepted spelling; name of river of creek into which it flowed; whether good for drinking; waterfalls; fords; ferries and anything of interest. The field surveyor also made a political tracing and kept a cost of survey form showing expenditure on salaries; allowances, labour guides transport etc.

The fieldwork was completed by June 1930 under the direction of Major J. Dare. The cost came to £69,000 and it was an outstanding low-cost topographical survey which has formed the basis of all mapping up to the present day. The accuracy of the work cannot be examined until the present 1:50,000 mapping is completed.

By 1931 some 32 sheets of the northern area had been published having been re-drawn and printed in the Surveys Department of the Gold Coast. Up to 1948 only these sheets had been printed out of the 104 sheets in the series. By 1950 the completed series were available having been drawn by the department but the printing was carried out by the Surveys Department of Gold Coast. It had not been possible because of staff shortage and lack of finance to carry out any field revision of the field sheets prior to publication.

After the Second World War it was agreed that Sierra Leone should be re-mapped and so in 1949 an R.A.F. photo reconnaissance squadron visited the country. The previous 123 astro-radio points were marked for photograph indentification. The 1949 photographs were poor and not acceptable for mapping and so the R.A.F. paid another visit in 1951 but with similar results.

In 1956 because of the urgent need for maps especially in connection with the geological development of Sierra Leone the Directorate of Overseas Surveys under the Colonial and Development Fund commenced aerial photography with a view to producing a series of maps at 1:50,000.

In 1958 the Directorate of Overseas Surveys as a result of an examination of the previous topographical control decided that it was not suitable for modern mapping, consequently, it was agreed that they would maintain a field party in the country to carry out a triangulation scheme. When Sierra Leone achieved independence in 1961, it was agreed to carry on the scheme under a United Kingdom technical co-operation scheme.

The field party started in 1958 and it was further decided to use the tellurometer for a trilateration scheme. At the present time about three-quarters of the country have been so observed. The low-lying areas in the south along the coast have been most difficult and towers had to be used. It is hoped that the trilateration scheme will be finished by early 1966.

At the present time some 36 sheets in the N.W. have been published and a further 17 sheets in the S.W. will be shortly available.

A technical report on this scheme will have to be delayed until the completion of the fieldwork and computation. The aerial photographs have been used by many government departments in planning development projects and their value cannot be too highly stressed.

The first edition of this series uncontoured but does have hill shading. The second edition will have contours at 50-feet vertical interval. The names for the second edition will be revised and this will necessitate considerable co-operation from other government departments and district officers. It is hoped to set up a committee of place names to ensure conformity with recommendations made by the Group of Experts on Geographical Names as set up by the Secretary-General of the United Nations in pursuance of resolution 715 A (XXVII) of the Economic and Social Council.

When the 1:50,000 mapping is completed it will be possible to produce more up-to-date and accurate maps at 1:1,000,000, 1:500,000, and 1:250,000. It has been agreed that the United States of America Army Map Service will produce the 1:250,000 series with information supplied by the Directorate of Overseas Surveys.

Certain special purpose maps at scales varying from 1:16,000 to 1:40,000 have been or are being produced for the Agricultural Division, Geological Division and Forestry Division. It is expected that further mapping in this connection will be required as the staffing of these departments permit and as the 1:50,000 series is completed.

A 1:10,000 series covering the Freetown Peninsula is being prepared but has to be delayed from time to time because of the constant need for revision prior to reproduction due to the increasing development of this area.

Cadastral surveying

The Freetown Peninsula about 35 miles by 8 miles was covered with a tertiary triangulation carried out in 1902 by Captain Pearson, R.E. A base at Hastings of 9,138 feet was measured for this triangulation. Starting in 1928 under the direction of Major J. Dare a cadastral survey of Freetown was based on this triangulation. The scale chosen was 1:1,250 and the vertical framework was based on the Mean Sea-level determination made by H.M.S. *Endeavour* in 1924. By 1930 a road map of Freetown was produced at a scale of 1:6,250.

In 1932 a cadastral survey of Bo was started covering 965 acres involving a framework of 14 miles of steel band traversing. This was executed by the African staff under supervision and they are reported as having performed their duties conscientiously, loyally and harmoniously. By 1933 seven sheets of Bo had been published.

In 1935 it was necessary to revise the Freetown 1:1,250 mapping and at the same time it was extended. Two extra sheets had been published and a further 3 in 1938.

After the Second World War in 1945 it was necessary to revise the Freetown mapping and also to extend it even further. This work continued to 1951.

During the period from 1948 to 1955 cadastral mapping was spasmodically carried out by field parties in some 8 up-country towns at a scale of 1:1,250. Unfortunately the process was so long and the development so rapid that the maps were often out-of-date even before publication. Also, since the department has no lithographic reproduction, the delay in printing seriously affected the general production.

In 1955 it was agreed to produce mapping of Freetown by aerial photography at a scale of 1:2,500. It was not until 1957 that the Fairey Air Survey Limited could start the actual photography. The department assisted the surveyors from Messrs. Fairey Air Surveys Limited in the control and field checking. These maps became available in 1959 and immediately it was found desirable to extend the mapping and this was completed by 1961. At the same time a 1:6,250 map of Freetown was published, and these map series have greatly assisted planning and development in the past 2 years. However, since Independence with the quickening pace of development it is becoming increasingly obvious that a revision will soon be required.

Under the United Kingdom Department of Technical Co-operation the Directorate of Overseas Surveys agreed to place a contact to photograph Bo, Kenema and Makeni in 1960-1961. Then in 1962 it was possible to photograph a further 3 towns i.e. Moyamba, Pujehun and Kailahun.

At the present time the sheets for Bo are being checked in the field whilst the control for Kenema is ready to be sent to the Directorate of Overseas Surveys. The control for Makeni is proceeding slowly because of lack of local staff.

A problem exists because of lack of senior and junior staff and it is hoped that the amendments necessary when the sheets are field checked will not be too great. The need for cadastral plans for the district headquarter towns is fully realized but because of the lack of trained staff this will have to proceed slowly.

Training

This leads to the necessity for continuous training schemes. The first Survey Training School was started

in 1925 to provide staff for the topographical mapping. The school was closed in 1930 and it was not possible to re-start it until 1947. The first intake was 12 students and it is interesting to note that 2 students subsequently obtained the Intermediate Examination of the Royal Institution of Chartered Surveyors and also 1 has recently passed the Final Examination. The School was, in 1951, recognised as an approved centre of training for the first examination of the Royal Institution of Chartered Surveyors.

Nevertheless, the School had to close in 1955 and an in-service system of training was tried but with little success. It was not re-opened until 1962 when a new superintendent was appointed.

The problem of training is two-fold because it is difficult to obtain suitably qualified training staff and it is also difficult to get students with the necessary background education who desire to become field surveyors or draughtsmen. This problem will no doubt exercise the minds of delegates to this conference.

Reproduction

The staffing problems affect the drawing office of the department and the lack of a lithographic printing press is regrettable. The department can reproduce plans by Ozalid printing, photostating, Thermofax and Gestetner. However it has been dependent on outside agencies for the reproduction of its mapping. This is becoming increasingly difficult as is recognized by the Sierra Leone Government including the provision of a lithographic printing press in the present 10-Year Development Programme. It has also been increasingly realized that such a press will assist materially in the preparation of diagrams and posters in connection with many other social development projects.

Atlas

The department published an atlas in 1951 but at the present time the stocks are extremely low. The compilation for a second edition proceeds but slowly but its publication is now a matter of some urgency.

Conclusion

The department also has a lands branch and because of its many problems particularly in land tenure, registration and lands administration it is becoming more and more obvious that planned expansion must take place. However, the staffing problems seem to get more immense and in a small country with many calls on its limited finance it is hoped that these problems will be solved through existing and projected technical assistance schemes.

MAP MAKING IN THE GEOLOGICAL SURVEY, SIERRA LEONE[1]

By Acting Director of the Geological Division of the Ministry of Lands, Mines and Labour

The first Geological Survey of Sierra Leone was formed in 1918. To it belongs the credit of preparing and publishing the first geological map of Sierra Leone, but unfortunately it failed to locate any mineral deposits of immediate economic value and it was disbanded on economic grounds in 1921. This first geological map was published in the *Report of the Geological Survey for the Year 1921*, Government Printing Office, Freetown.

The *Provisional Geological Map of Sierra Leone*, which was published by the department in 1929, was revised and brought up to date in 1930-1931, and a limited number of copies were printed and were on sale at the Mines Office, Freetown, at 5s. each. Probably this map was prepared for printing at the Imperial College of Science and Technology, London, where the geological staff used the laboratories while they were on leave. No laboratory or drawing office facilities were available in Freetown. In 1938 a geological map of Sierra Leone on the scale of 1:500,000 was prepared but was not published. In 1947 geological investigations were resumed and in 1949 the department was expanded. Various attempts to produce geological maps using the old 1:62,500 topo series as a base were tried but no real progress was made until the base maps were switched from this series to 1:32,000 aerial photo maps in 1957 and 1952 and produced the topographic base map of the Sula Mountains. In 1955 the department obtained the services of a part-time cartographer, who prepared topographical maps of the areas to be geologically mapped from aerial photographs on the scale of 1:32,000 and so relieved geologists from this work. The cartographer also drew the final copies of geological sheets on the scale of 1:32,000 preparatory to their reduction in England for printing on the scale of 1:50,000; the Directorate of Colonial Surveys printed these maps without charge.

Real progress began to be made mid-1958 in the production of topographical base maps on which the geology of the area is plotted, and of the final version of the geological sheet ready for printing and publication. The fundamental task of any geological survey is to map, produce and publish geological maps of the country on a scale large enough to record information which may be of value to individuals or organizations engaged in mining or engineering investigations. During 1957, sheets 1 and 2 of the geology of the Sula Mountains-Kangari Hills schist belt had been published on the scale of 1:50,000 and were put on sale in the Government bookshop at 5s. each; 1958 saw the completion of sheets 3, 4 and 5 of the geology of the Sula Mountains-Kangari Hills in their final form.

The division at this time began to purchase larger items of equipment for the drawing office. A slotting template machine was bought and topographic field sheets were compiled with all the accuracy that the quality of the

[1] The original text of this paper, submitted by Sierra Leone, appeared as document E/CN.14/CART/55.

available air photographs and the number of known fixed points would allow.

The contract aerial photography being flown at this time at the scale of 1:40,000 was of very good quality compared to the old R.A.F. photography and it was anticipated that the quality of the topographic base maps could also be improved.

The drawing office staff now (1963) consists of the cartographer and six assistants of various grades.

MAJOR CARDINAL SURVEYS FOR AGRICULTURAL DEVELOPMENT IN THE SUDAN[1]

Introduction

The natural resources of the Sudan are primarily land and water and hence its economic structure depends in the first place on agricultural development. For this reason the cadastral surveys of major agricultural schemes and the survey and settlement of property affected by these schemes have been given the top priority over all survey programmes. The following account illustrates some of the major cadastral surveys undertaken in the Sudan together with a historical review of the methods adopted in those surveys.

Gezira survey

The survey of the Gezira land, which is situated between the Blue and White Niles and bounded by latitudes 13°30′ and 15°15′ North was the first major cadastral survey undertaken in the Sudan (1907 to 1927). The purpose of the survey was a twofold one (*a*) to provide contours at half metre intervals on scale 1:20,000 for the design and execution of irrigational works and (*b*) to prepare registration plans on scale 1:4,000 showing the private and government lands. An area of approximately 4.4 million feddans[2] was surveyed in this connexion of which one million feddans were developed, in stages before Sudan Independence into what is now known as the "Gezira Scheme" and a further 800,000 feddans were developed after independence into the "Manaqil Extension". Both areas being irrigated by gravity from Sennar Reservoir on the Blue Nile (lat. 13° 34′, long. 33°33′ East of Greenwich). A system of rectangulation based on the demarcation of one-terrestrial-minute squares, by theodolite and tape traversing, was adopted. This system, in addition to its providing the irrigation engineer with the necessary skeleton for the execution of his canalization, also furnishes the administrator with the geographical positions which serve as land marks in a flat featureless terrain. The corners of the minute squares were marked with iron beacons 12 feet long having two cross plates on top of each beacon which bear the geographical co-ordinates. The plates are oriented so as to indicate the four directions. This system is known in the Sudan as the "Gezira Beacon System".

Rain lands survey

In 1948 when the Sudan Government decided to introduce mechanized methods for production of rain crops, the Survey Department was faced with the problem of surveying extensive areas, full of bush and tall grass, in a relatively short time. To use the "Gezira Beacon System" with its short and too close together beacons for such areas would have meant a great deal of extra work, which would no doubt have lead to the retardation of rainland development. It was then thought to evolve some quicker and more economical system of demarcation for bushy areas, in which accurate registration may never be required. As a consequence to this idea a new concrete pole 26 feet long, of which 6 feet were buried in the ground, was designed. Instead of being set out in one minute squares the poles were fixed by car and compass in approximately straight North/South and East/West lines about 4.5 km apart, i.e. at approximately 2½-minute intervals, and were then connected to each other by fourth order triangulation. Holes had been made through the pole so that lengths of channel iron could be inserted and used as steps which made it possible for a chainman to climb to the top of the pole. On the top of the pole a threaded pipe of 1½″ diameter was set during casting in order to hold an adapter to which a theodolite or helio was fixed. A special iron tripod platform was designed for the observation.

The advantages of this system are:

(*a*) Very little bush clearance is involved and so the time taken in establishing a control net is very much less than it would have been if the other beacon system had been used;

(*b*) The pole is visible from very much further away than the Gezira pattern beacon;

(*c*) Not being metal the pole is less likely to be damaged and should be less costly to maintain.

The disadvantages of the system are:

(*a*) The heavy weight of the pole (500 kg) makes its transportation expensive especially to areas that are distant from casting places;

(*b*) It is difficult to emplace a pole exactly vertical and even if verticality is maintained during the erection time, the pole is liable to lean to one side after the first rainy season.

(*c*) The interval between the poles cannot be kept regular throughout the same area as this depends on the height of trees and on ground undulations;

(*d*) The poles, being farther apart than the Gezira beacons and irregularly emplaced, makes this system unsuitable for artificial irrigation projects;

(*e*) The vibration of the poles at both instrument and signal ends makes it difficult for the observer to attain good results.

Later and after nearly six years from its introduction, the use of this system for the demarcation of mechanized

[1] The original text of this paper, submitted by the Sudan, appeared as document E/CN.14/CART/42.

[2] One feddan measures 4,200 square metres or 1.038 acres or 0.42 hectares.

crop production schemes was abandoned. Instead, a rectangulation system of 2 × 2 kilometre squares was introduced for such schemes in order to cater for (*a*) the necessary survey control and (*b*) the provision of equal area plots to be distributed to the prospecting farmers. The demarcation of these squares was carried out by theodolite and tape traversing.

Kenana survey

Towards the end of 1957 the Survey Department was requested to demarcate and contour an area of approximately 3 million feddans which would be irrigated by gravity from a projected reservoir[3] on the Blue Nile South of Roseires (lat. 11°47′ North, long. 34°23′ East of Greenwich). This area, known as Kenana Scheme, is situated south of the Gezira Scheme between latitudes 11°47′ and 13°30′ North. It is covered with various species of bushes and trees with small patches of cleared land. After weighing the various systems of control, it was decided to adopt the "Gezira Beacon System" for its simplicity and familiarity to the irrigation engineer, the settlement officer, the administrator and the local people as well. To speed up the traverse work involved in the said system, it was decided to use bulldozers for bush clearance and tellurometers for distance measurement. A special concrete beacon 10 feet long was designed to replace the old iron pattern, which was often destroyed by nomads or removed by mischievous persons.

Before launching on this major survey, tables of distances covering the whole area were prepared for every minute of arc measured along the meridian and parallel, together with offsets from tangent to parallel at every minute using Clarke 1880 figure. Tables were also prepared for mean sea level corrections to be applied to both meridian and parallel distances for heights ranging from 380 to 480 metres above mean sea level at 10-metre intervals. The initial point of the survey was determined by astronomical latitude and longitude observations to second order standards. The initial meridian was determined by azimuth observations taken to polarisation.

The demarcation was carried out by two survey officers and four assistant surveyors with an adequate number of chainmen and labourers. The setting out of angles was carried out with a Wild T2 theodolite and the linear measurement by a combination of tape and tellurometer model MRA 1.

At the start a tangent is set out at right angles to the initial meridian. Distances of 1,817 metres[4] along the tangent and 1,845 metres[5] along the meridian are measured roughly with tape placings pegs at the end of each distance and at chainage 1,800 metres along the tangent and 1,840 metres along the meridian. This rough measurement is carried out by chainmen during the process of bush clearance with one of the assistant surveyors carrying out the rough alignment of the pegs by binoculars and ranging rods. After clearing a length of 5 minutes either way, the final alignment is quickly done by a leap-frog method using two T2 theodolites. One survey officer sets his theodolite at the initial station and aligns the pegs of the first beacon and then moves to the second one. The other survey officer then sets his theodolite at the end peg of the first beacon and aligns the pegs of the second beacon and moves forward to the third one and so on until the alignment of five beacons has been completed. Ordinary ranging rods are used for alignment and the signalling is made with a large survey umbrella. At the signal end two chairmen stand to receive the alignment signals, one of them carrying a binocular and the other holding a ranging rod. At the end of the alignment the tellurometer measurement is started from the last beacon and run backwards towards the initial point. The remote instrument is set on the last beacon and the master is set on the beacon before the last. After the master operator has finished his readings for the first distance, he signals the remote operator to move to the next station. While the latter is shifting from one station to the other, the former proceeds with the reduction and computation of his readings.[6] The measurement is continued till the initial point has been reached.

This procedure is usually adopted in the morning, the alignment, being carried out during the first two hours after sunrise in order to eliminate the effects of lateral refraction caused by heating up of bushes along the two sides of the cleared lines. In the afternoons, this method of combining alignment and measurement is not workable owing to the very short period suitable for alignment. (Usually one and a half hour before sunset.)

When the distances between the pegs have been finally computed, the position of every end peg is adjusted by stretching a tape between the end peg and the other one behind it and then moving the end peg to its correct position which is eventually the beacon position along the meridian. Along the tangent, offsets are measured from the correct pegs northwards in order to fix the right beacon positions along the parallel.

Each five-minute square is adjusted by taking azimuth observations at two of its corners. The maximum allowable error between the observed and deduced azimuth being 10″ or in other words a linear error of 1:20,000; the probable error of astronomic azimuth not exceeding 3″.

After fixing the final beacon positions on the perimeter of the five-minute square, the intermediate four meridians are then set out with theodolite and tape by the four assistant surveyors starting from one parallel and closing on the other. The taping is usually carried in a piece-meal manner during the process of clearance. The resulting misclosure at the terminal beacon, which should not exceed 1:10,000, is distributed proportionately to the four intermediate beacons.

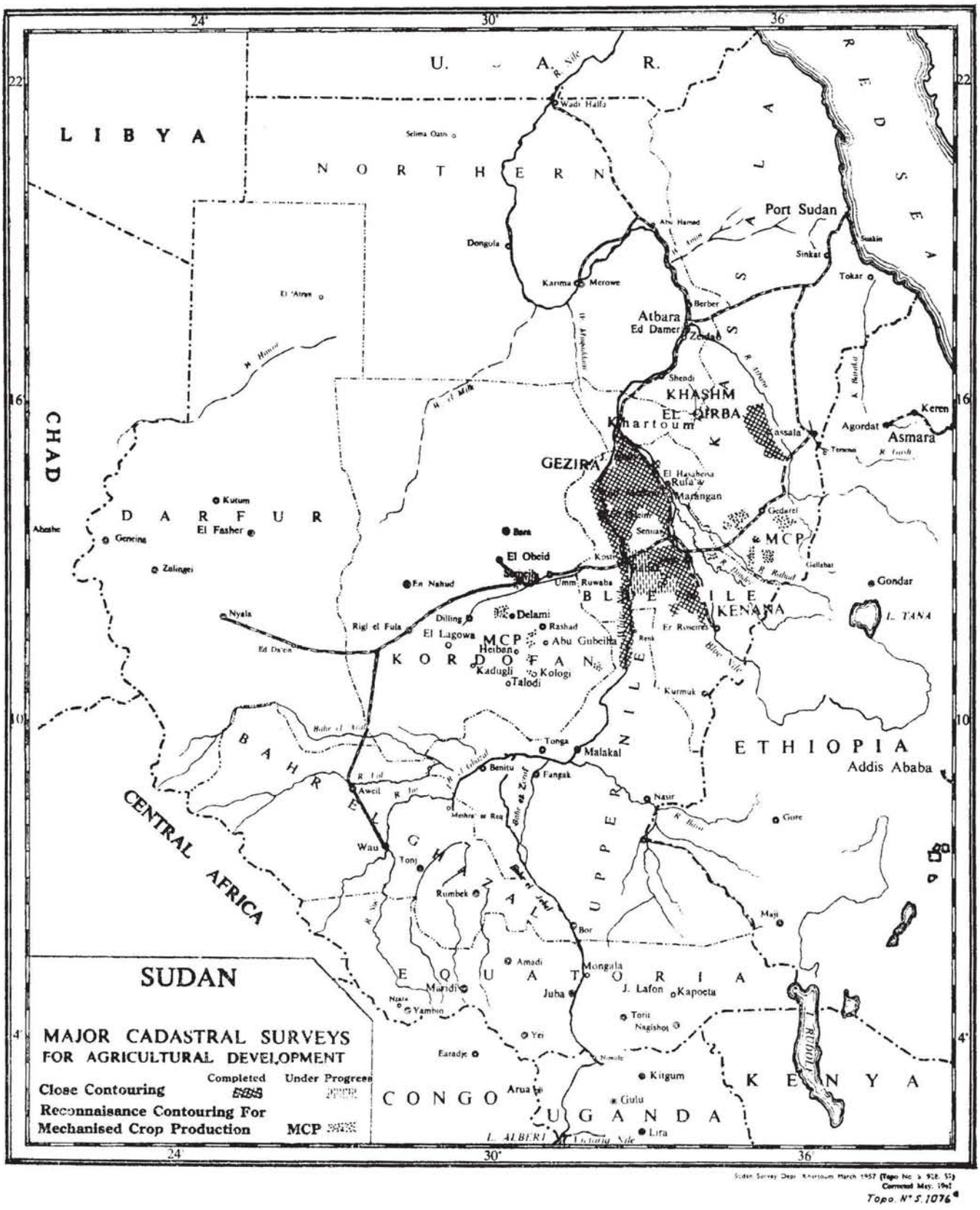
When all beacon positions have been finally fixed the emplacement of concrete beacons begins. Before emplacement, a circular concrete underground mark is plumbed downwards to the bottom of every ditch to represent the exact position of the beacon. The under-

[3] This reservoir is now under construction.

[4] The length of one minute of arc measured along the parallels ranges between 1,804 and 1,817 metres.

[5] The length of one minute of arc measured along the meridian being 1,843 metres plus fraction of a metre.

[6] With the introduction of the MRA 2 and 3 Tellurometer models, this procedure could be modified to allow for three surveyors to do the measurement.



Sudan: major cadastral surveys

ground mark is covered with earth and the beacon is then placed vertically on top of it. If any beacon is destroyed or knocked off its position it could be re-established by erecting it over the said underground mark. In addition to the emplacement of beacons, the demarcation party is supposed to establish pile bench marks[7] at every three beacons apart.

A month after the demarcation party has started its activities, a levelling party consisting of one survey officer, ten levellers and two draughtsmen, follows the former party. This party runs cross sections at 600 metre intervals with spot heights taken every 300 metres along the cross sections. In addition to the levelling the party surveys all features in the area such as water courses, roads, villages, forest reserves and existing pump schemes etc. Field plans scale 1:20,000, showing spot heights and other features are prepared by the party before it leaves a particular area.

Since 1957 the survey of Kenana was interrupted several times and the parties engaged on it were switched to other urgent development surveys. The shortage of technical trained staff being the main factor behind the interruption of the survey programme. Up to now about 1.3 million feddans of this scheme were completed. The average monthly output depended totally on the volume of bush clearance. It ranged from 55,000 feddans in thickly wooded areas to 85,000 feddans in areas where bushed approximately covered half of it. In Khashm el Qirba, where a major scheme is now under execution[8] the average monthly output for similar parties was 160,000 feddans. Approximately 10 per cent of this area was covered with bushes.

The over-all cost per feddan varied from one area to the other depending also on the volume of bush clearance. In Kenana it varied from 126 to 92 milliemes per feddan and in Khashm el Qirba the cost per feddan was 51 milliemes.[9] These costs include salaries of permanent staff, wages of daily labourers, allowances, motor transport and hire of bulldozers for bush clearance. The cost of of bush clearance being 35 per cent of the over-all cost.

Comparing costs of similar surveys carried without the help of the tellurometer, it can safely be claimed that the use of the tellurometer has reduced the cost per feddan to nearly half what it would have been if classical methods have been used.

[7] A pile benchmark is made of a 2″ diameter pipe two metres long with a square bed plate at its bottom and a circular cap on its top. It is sunk 1.8 m in ground with a concrete cover grouted on top of it.

[8] A dam for irrigating half a million feddans of this scheme is now under construction. Part of this scheme is being designed for the resettlement of about 50,000 of the population of North Sudan whose lands will be inundated by the backwater curve of the High Aswan Dam (Sud el 'Ali).

[9] One British shilling equals approximately 50 milliemes.

REPORT ON CARTOGRAPHIC ACTIVITIES IN THE SUDAN (1935-1963)[1]

General

All cartographic activities in the Sudan are carried out by the Survey Department, which was founded in 1900. The Survey Department is now an agency of the Ministry of Mineral Resources, to which Ministry also belongs the Geological Survey Department.

This report is a brief description of cartographic and related activities in the Sudan since 1935 with a short historical review of work done before then.

Geodetic surveys

(a) *First and second order triangulation*

Prior to 1935 a series of rapid triangulation chains, which are now termed as "old triangulation", were carried out in rather a piece-meal manner in order to meet the basic requirements for topographical mapping, especially along the Sudan frontiers. No permanent beacons were built on the triangulation stations as only stone cairns were then used. Although the old triangulation was not up to geodetic standards, yet it had been very useful in compiling the planimetric 1:250,000 series. The map on page 127 illustrates the old triangulation carried out before 1935.

Geodetic triangulation was started in 1935 by continuing southwards the observations of the arc of the 30th meridian carried out by the Survey of Egypt from the Mediterranean to Adindan (approximately latitude 22° N). The progress in this arc has been very slow due to the limited financial funds allocated to it at that time and to holding it up during the Second World War. The horizontal directions south of the tenth parallel were observed by the United States Army Map in 1952-1954. All other first and second order chains observed in the Sudan were connected to this arc. Three of the first chains observed between 1960 and 1963 have been accomplished in co-operation with USAID and United Nations. All directions observed before 1960 were done with geodetic Tavistock theodolites and after 1960 with Wild T3 theodolites. 4,280 km chains of first order and 1,400 km chains of second order triangulation have been completed. All stations were built on hill tops with the exeption of 39 stations where bilby steel towers have been used. In general, 16 zeros were taken at each first order station and 8 zeros at each second order station.

Ten bases, 90.3 km long, were measured by the Sudan Survey Department with invar tapes hung in catenary and 3 bases 52.2 km long were measured by the United States Army Map Service with a geodimeter.

The origin of the triangulation is the south-western terminal of Adindah base situated in the United Arab Republic. The computations have been made on the modified Clarke 1880 figure. The geodetic triangulation is shown diagrammatically on page 128.

[1] The original text of this paper, submitted by the Sudan, appeared as document E/CN.14/CART/43.

(b) *Precise levelling*

Precise levelling was begun in the Sudan by the Survey of Egypt and the Egyptian Irrigation Department for the study of the hydrology of the Nile. 5,120 km were done in this connection. Since 1935 the Sudan Survey Department has completed in double levelling a distance of 6,024 km covering 16 sections of precise lines. All levelling north of Khartoum is referred to mean sea level at Alexandria with the zero of the Nile gauge at Khartoum being determined as 363,000 metres. Levels south of Khartoum, which were carried before determination of the accurate value of the gauge zero, had been referred to an arbitrary value of 360,000 metres.

An automatic tide gauge station was built at Port Sudan harbour on the Red Sea in October 1960. All Sudan levels will be connected to it when the mean sea level of the Red Sea at the harbour has been finally determined.

The levelling from Atbara to Khartoum and from Kosti to Sennar closed two circuits with the following results:

Circuit	*Perimeter (km)*	*Total misclosure (mm)*	*Misclosure (mm per 100 km)*
Khartoum-Sennar-Showak-Atbara-Khartoum	1,384	−128	− 9.2
Khartoum-Kosti-Sennar-Khartoum	712	−96	−13.5

"The closing errors may be vitiated to some extent by discontinuities in the field observations from season to season and over larger periods, for though a check was always made on three old bench marks before advancing at the start of a fresh season, in the case of pile bench marks it could only reveal their relative, as opposed to their absolute, movements in clay soil". (Quoted from Sudan National Report on Geodesy, 1957.)

The precise level lines accomplished so far are shown on page 128.

(c) *Gravity measurements*

Gravity measurements at the fundamental station, situated at the University of Khartoum, were taken by the Sudan Survey Department in 1935-1936 using a Cambridge pendulum.

Connections between Khartoum and Washington were made in 1955 by observers from the University of Wisconsin using Gulf pendulums. In 1958 the station was reconnected to Rome by an observer from the Department of Geodesy and Geophysics of Cambridge University using Cambridge pendulums. The following were the results of those measurements:

	g
1936 datum	
Cambridge Pendulum House	981.2682
Khartoum	978.3034
1955 datum	
Washington Geophysical Laboratory	980.1007
Khartoum	978.3029
1958 datum	
Rome—National Geophysical Institute at the University	980.3637
Khartoum	978.3028

In 1962 measurements were taken by observers from the Geodetic Institute of Hanover with Askania gravimeters. Measurements were based on the European Calibration System. Final results are not yet available.

TOPOGRAPHICAL MAPPING

(a) *1:250,000 series*

These sheets are based on the former standard GSGS African series and are grouped together in rectangular blocks of sixteen sheets, denoted by a number to give the same coverage as the *International Map of the World on the Millionth Scale*. Each sheet covers an area of one degree in latitude by one and half degrees in longitude and are lettered from A to P within the block. The sheets are plotted on a modified polyconic projection.

Mapping in this series was begun in 1900 to satisfy immediate administrative requirements at that time. Up to 1950 the compilation of topographical details depended totally on planetable surveys and compass traverses controlled here and there by astronomic latitude and longitude or by latitude and azimuth. Since 1950 trimetrogon and vertical photography has been used for revision of these series with very little progress due to shortage of staff. Only 11 sheets out of the 167 sheets covering the country were revised. The map on page 129 indicates that the revision was confined to areas not covered by the old triangulation or in areas under development.

(b) *1:100,000 series*

The 1:100,000 series was begun in 1948 to serve as reconnaissance maps for development projects in areas where the 1:250,000 maps were considered to be too small for the purpose. Later, it was decided to adopt this scale for the main topographic series of the whole country with the exception of desert and semi-desert areas in the North and North-West Sudan.

When first started, this series was prepared by direct enlargement of the 1:250,000 old maps with little addition and correction of water courses and tracks from trimetrogon photography. Place names were entirely copied from the 1:250,000 series. In very few cases names were added or corrected from recent large scale surveys of small areas falling in the respective sheet. These maps, being provisional editions, were first published in one colour using the same specifications as the 1:250,000 series.

No hard and fast programme for mapping in this scale was planned until recently and hence no single sheet was completely brought up to date. Yet a few sheets were improved by the addition of more features from vertical photography, whenever a pressing need arose for a better map required for detailed planning. Up to now, only one sheet west of the Nile near Khartoum has been prepared from a 100 per cent photographic coverage. The index shown on page 130 covers 129 sheets of the provisional edition of this series and 18 sheets of semi-final edition published in multicolours. The sheets are 30 × 30 minutes in size bearing the same number as the parent 1:250,000 sheet with number suffixes from 1 to 6. They are plotted on Traverse Mercator Projection with East Africa Belts (5°wide).

(c) *1:50,000 and larger series*

In 1962 it was decided to adopt the 1:50,000 and

1:25,000 scales as standard topographic series for development projects with sheet sizes of 15 and 7½ minute-squares respectively. Rectangular co-ordinates based on the Traverse Mercator Projection with East Africa Belts were superimposed on the sheets. Scales larger than 1:25,000 were used for engineering projects such as the special maps prepared for Khashm el Qirba Dam Site on scales 1:10,000 and 1:500. Only 6 sheets scale 1:50,000 have been completed under the new series.

Before 1962 several maps on scales ranging between 1:50,000 and 1:15,000 and based on different grid systems were accomplished.

The map on page 131 shows the mapping coverage on scales 1:50,000 and larger irrespect of regularity or standard of the series. This includes 203 sheets on 1:50,000; 95 sheets on 1:25,000; 146 sheets on 1:20,000; 18 sheets on 1:15,000; 12 sheets on 1/5,000; and 12 sheets on 1:5000.

Aerial photography

Prior to 1950 trimetrogon photography, taken by the United States Air Force during World War II, was used for map compilations, but this type of photography proved to be unsuitable for the Sudan because of the country's general flat topography.

In 1950 a Dove Plane was modified to take a Williamson camera and since then vertical photography was introduced in the Sudan. In 1954 the Williamson was replaced by a Wild RC8 camera fitted with Avitar 21 cm, Aviogon 11.5 and 15 cm and Infragon 11.5 cm cones. In 1959 the Dove was replaced by a Dakota (DC3) specially modified to suit flights at higher altitudes. A Decca Doppler System and a gyro stabilized drift-meter were introduced in the same year for navigation.

The aerial photographic coverage shown on page 132 comprises vertical photography for all purposes, flown at various altitudes with various lens cones selected to give the requisite scale for each individual job. Photography at contact scale 1:40,000 is flown for the purpose of land use, water and geological investigations using 18 × 18 cm format and 11.5 cm lens cone at an average flying altitude of 5,000 metres above sea level.

Scales 1:33,000 to 1:20,000 are used for forest and soil surveys and for major agriculture projects. Either of the 18 × 18 cm or 23 × 23 cm format with one of the three lenses are used. Scales 1:20,000 to 1:5,000 are used for village and town planning and for engineering projects.

So far very little has been achieved in using aerial photography for topographic mapping, as most of the time of the mapping unit is confined to preparation of mosaics for developments projects. Six sheets on scale 1:25,000 with 5 metre contours covering an area of 1,000 sq.km. and one sheet scale 1:10,000 with 5 metre contours covering an area of 34 sq.km. have been prepared from aerial photographs. Plans of 8 villages on scale 1:1,000 covering an area of 17.5 sq. km. were also prepared from aerial photographs.

The photogrammetric equipment and facilities include 8 Wild Mirror Stereoscopes, Zeiss Stereo Point Transfer Tools, 2 Zeiss Radial Secators, various Sketchmasters, one Zeiss Sterectope, 2 Wild Autographs A7 with electronic co-ordinate printers, 6 Wild Autographs A8 and a large size Coradi Co-ordinatograph. Some of this equipment was procured through USAID.

The photographic laboratory is fully equipped for developing air films, manual and electronic contact printing, photographic reproduction and enlarging. The equipment includes a modern large size copy camera, 3 Cintel Printers and a Zeiss seg V Rectifier.

In September 1959 the Government was fortunate to have one of the United Nations experts to train the personnel of the Photogrammetric Section for a period of one year. Another United Nations expert was attached to this section in January 1962 for two years. A third expert was employed through USAID programme in December 1961 for two years also. Two candidates studied photogrammetry under USAID programme in the International Training Centre of Delft. A third candidate had also completed a course in photogrammetry at Delft under a United Nations fellowship and a fourth candidate is now taking the same course under a fellowship presented by the Government of the Netherlands to the Economic Commission for Africa. Another two candidates spent two years training at Wild Works practising repair and maintenance of stereoplotting machines and other field survey instruments under USAID Programme.

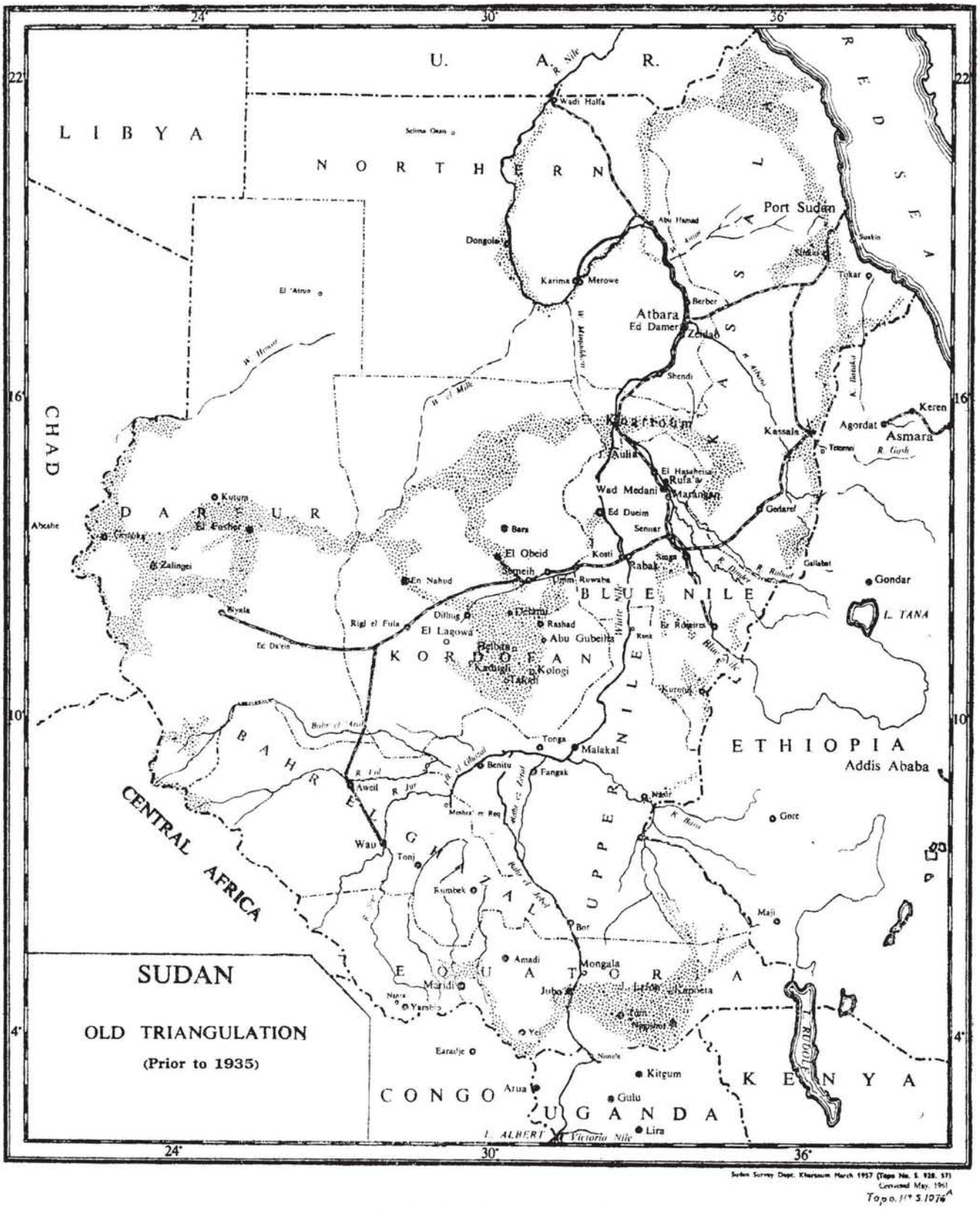
Cadastral surveys

The standard scale for registration plans of agricultural lands varies from 1:2,500 in riverain areas of the Northern province, where the land is divided into small parcels, to 1:4,000 and 1:5,000 in riverain and rain lands of the Blue Nile Province. From these registration scales, general plans (Keymaps) are prepared on scales 1:10,000 and 1:20,000 in the respective areas.

In the Northern Province, the original survey of riverain lands was started in 1900. Each sheet covering a registration section was surveyed independently on magnetic bearing without any link between the two banks of the Nile. The appearance of newly formed islands after the original survey had led to hot disputes and between fights the owners of land on opposite banks. The situation became even worse after an exceptionally high flood in 1946 which washed out most of the boundary marks and led to disputes between neighbouring owners. In 1950 an extensive programme for the resurvey and resettlement of these lands was begun and since then an area of 152,000 feddans[2] has been resurveyed. The survey was controlled by theodolite and tape traverses tied to second order triangulation. The survey of parcels was done by planetabling and plans were plotted on the Traverse Mercator Projection on scale 1:2,500.

The standard scale for registration plans of townships varies from 1:1,000 for residential plots to 1:500 for market areas. General plans are prepared in scales ranging from 1:2,000 to 1:10,000. The work is controlled by theodolite and tape traverses based on rectangular co-ordinates and all plots are measured by chain. Plans of existing villages are now being prepared from aerial photography con-

[2] One feddan measures 4,200 square metres or 1.038 acres or 0.42 hectares.


SUDAN
OLD TRIANGULATION
(Prior to 1935)
U. A. R.
LIBYA
CHAD
CENTRAL AFRICA
ETHIOPIA
KENYA
UGANDA
CONGO
NORTHERN
DARFUR
KORDOFAN
BLUE NILE
BAHR EL GHAZAL
EQUATORIA
UPPER NILE
Khartoum
Port Sudan
Atbara
Ed Damer
Dongola
Merowe
Wadi Halfa
Shendi
Kassala
Asmara
Agordat
Keren
Gondar
Addis Ababa
Wad Medani
Ed Dueim
El Obeid
En Nahud
Kosti
Rabak
Sennar
Singa
Gallabat
Kutum
El Fasher
Zalingei
Abeche
Bara
Rashad
Abu Gubeiha
El Lagowa
Dilling
Talodi
Kadugli
Kologi
Tonga
Malakal
Benitu
Fangak
Wau
Tonj
Aweil
Rumbek
Bor
Mongala
Juba
Maridi
Yambio
Amadi
Yei
Kitgum
Gulu
Lira
Arua
Gore
Maji
Lafon
Kapoeta
Torit
Narus
Kurmuk
Singa
Gedaref
Tessenei
Keren
Sinkat
Suakin
Berber
Abu Hamad
Omdurman
Khartoum
Rufa'a
Hasaheisa
Maiurno
Renk
Melut
Nasir
Pibor
Pochalla
Nimule
Kajo Kaji
Yei
Yambio
Nzara
Tambura
Raga
Meridi
Amadi
Mongala
Juba
Bor
Maji
Gore
Lafon
Kapoeta
Torit
Kitgum
Gulu
Lira
Arua
Nimule
Pochalla
Nasir
Melut
Renk
Kurmuk
Singa
Gedaref
Tessenei
Keren
Agordat
Asmara
Sinkat
Suakin
Berber
Abu Hamad
Omdurman
Khartoum
Rufa'a
Hasaheisa
Maiurno
Wad Medani
Ed Dueim
Sennar
Rabak
Kosti
Singa
Gallabat
Gondar
L. TANA
Tonga
Malakal
Benitu
Fangak
Wau
Tonj
Aweil
Rumbek
Bor
Mongala
Juba
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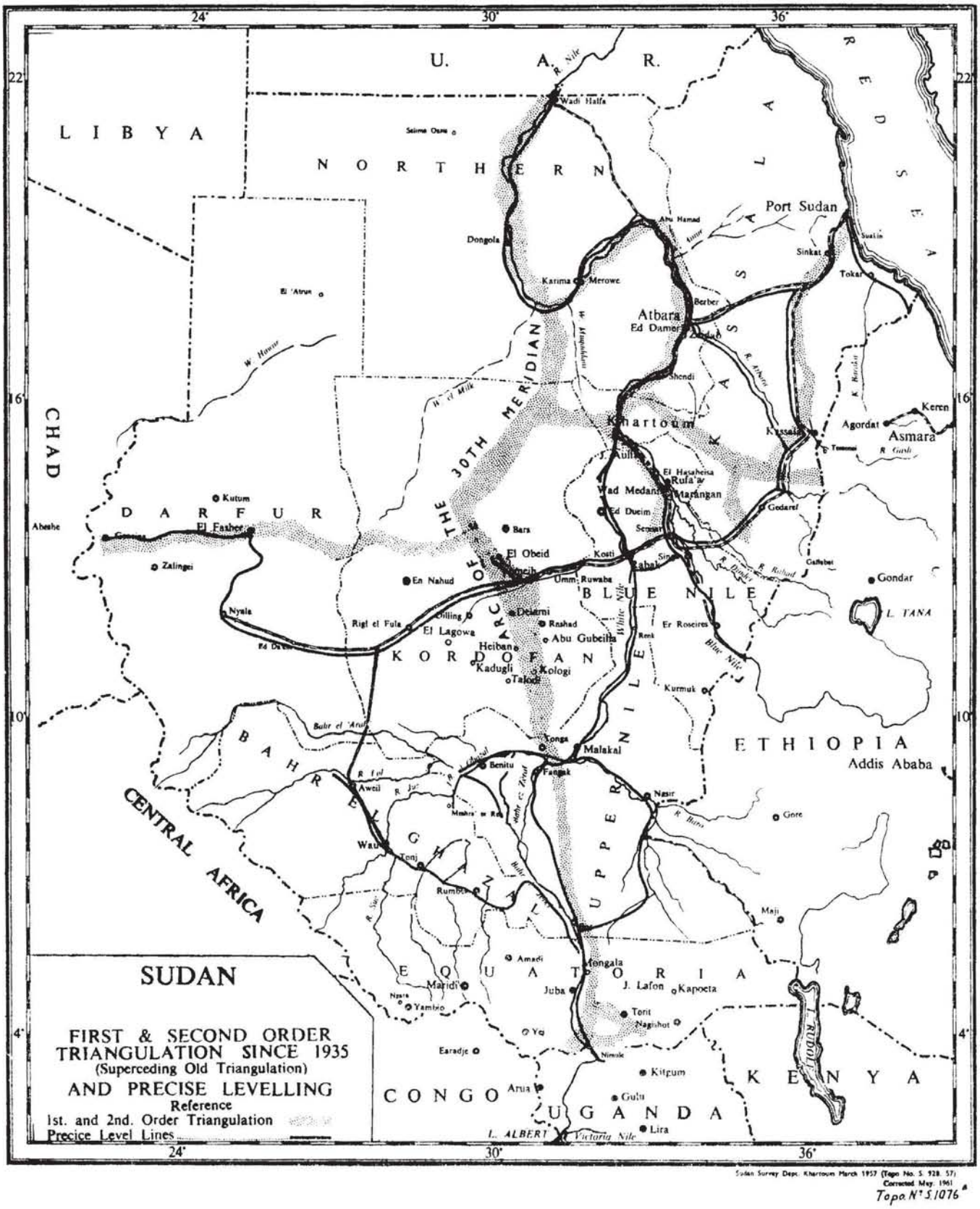
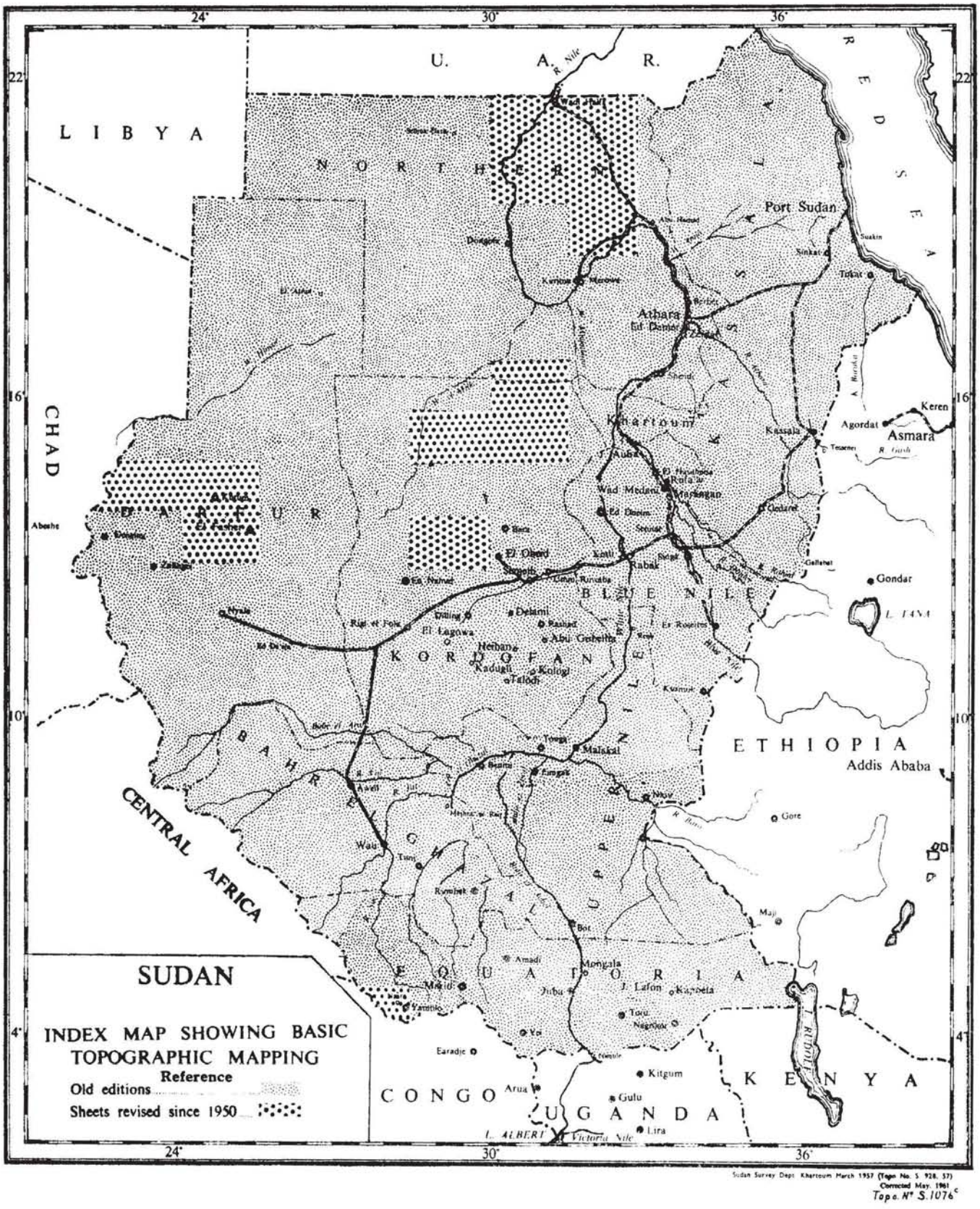
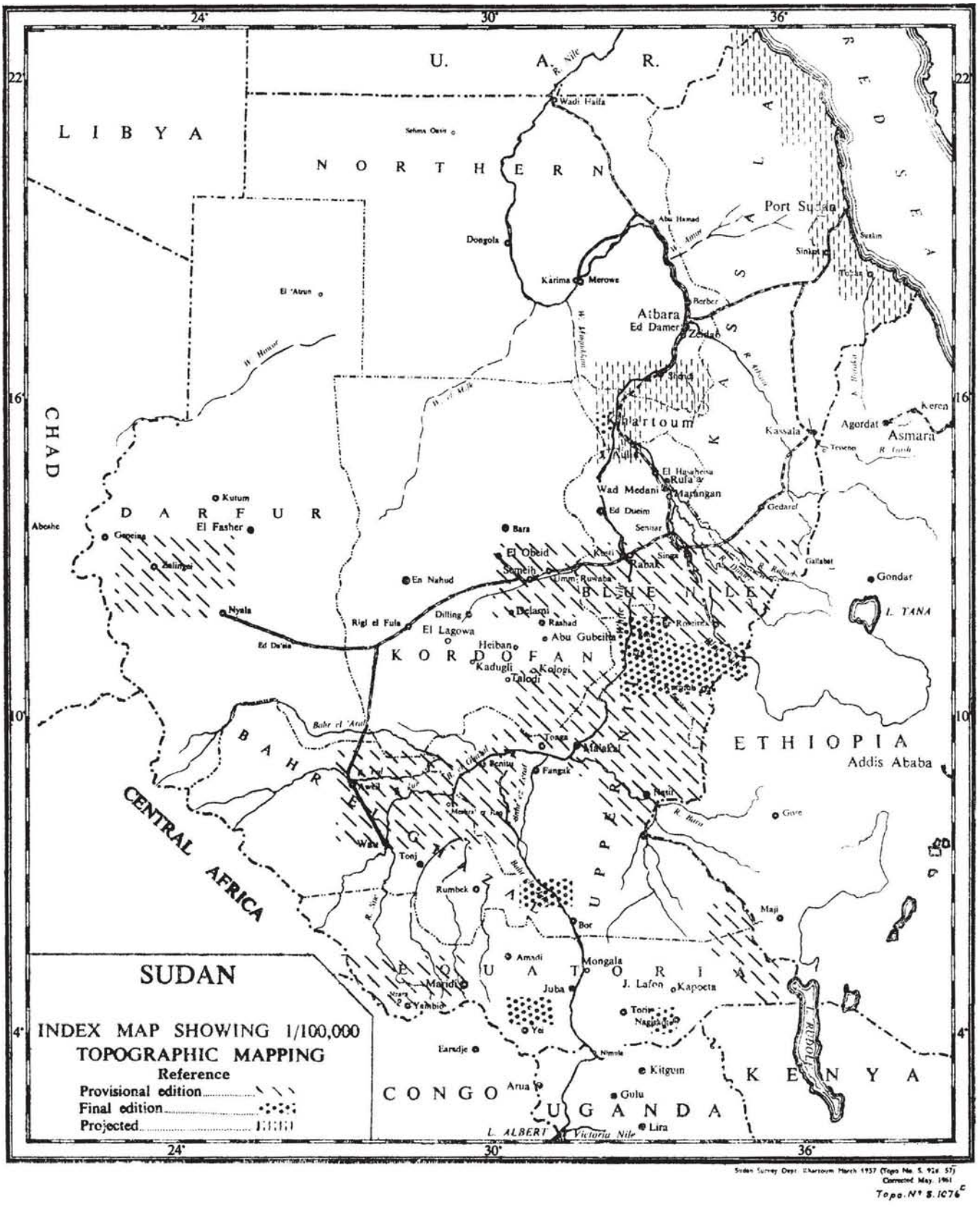
Kapoeta
Torit
Narus

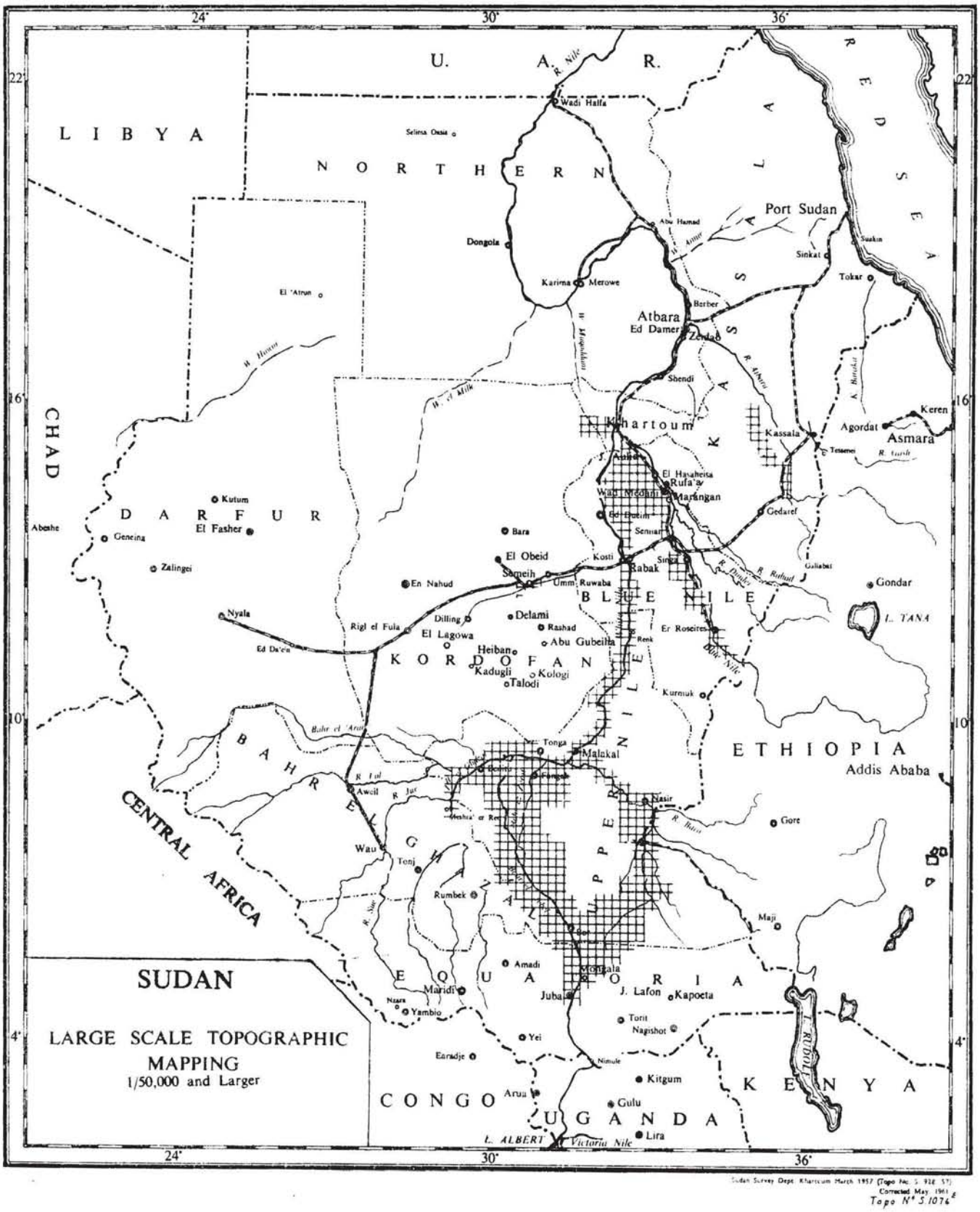

SUDAN
FIRST & SECOND ORDER TRIANGULATION SINCE 1935
(Superceding Old Triangulation)
AND PRECISE LEVELLING
Reference
1st. and 2nd. Order Triangulation
Precice Level Lines
U. A. R.
LIBYA
CHAD
CENTRAL AFRICA
CONGO
KENYA
ETHIOPIA
UGANDA
NORTHERN
DARFUR
KORDOFAN
BLUE NILE
KASSALA
RED SEA
THE 30TH MERIDIAN OF LONGITUDE
Port Sudan
Khartoum
Atbara
Ed Damer
Dongola
Wadi Halfa
Abu Hamad
Sinkat
Tokar
Berber
Shendi
Kassala
Kerem
Agordat
Asmara
Gedaref
Gondar
L. TANA
Addis Ababa
Kutum
El Fasher
Zalingei
Nyala
Bara
El Obeid
En Nahud
Umm Ruwaba
Kosti
Rabak
Sinja
Ed Dueim
Wad Medani
Rufa'a
Marangan
El Hasaheisa
Delami
Rashad
Abu Gubeiha
El Lagowa
Heiban
Kadugli
Kologi
Talodi
Er Roseires
Kurmuk
Renk
Malakal
Fangak
Benitu
Songa
Nasir
Gore
Maji
Mongala
Juba
J. Lafon
Kapoeta
Torit
Nagichot
Kitgum
Gulu
Lira
Arua
Yambio
Maridi
Amadi
Yei
Nimule
Rumbek
Tonj
Wau
Aweil
Meshra' er Req
L. ALBERT
Victoria Nile
White Nile
Blue Nile
Sobat
Bahr el Arab
R. Jur
R. Lol
R. Sue
R. Bisie
R. Bilia
R. Atbara
R. Rahad
R. Dinder
R. Gash
R. Barka
Gallabat
Keren
Tessenei
Salima Oasis
El 'Atrun
W. Howar
W. el Milk
W. Muqaddam
Abeshe
Geneina
Zalingei
Rigl el Fula
Dilling
Umm Dafug
Bahr el Arab
Meshra' er Req
Aweil
Wau
Tonj
Rumbek
Yambio
Maridi
Yei
Juba
Nimule
Mongala
Amadi
Yambio
Nzara
Yei
Easadje
Arua
Gulu
Lira
Kitgum
Nagichot
Torit
J. Lafon
Kapoeta
Maji
Gore
Nasir
Malakal
Fangak
Benitu
Songa
Kurmuk
Renk
Er Roseires
Blue Nile
White Nile
Sobat
Rabak
Kosti
Sinja
Ed Dueim
Wad Medani
Rufa'a
Marangan
El Hasaheisa
Gedaref
Gallabat
Gondar
L. TANA
Kassala
Tessenei
Keren
Agordat
Asmara
Tokar
Sinkat
Suakin
Port Sudan
Abu Hamad
Berber
Shendi
Atbara
Ed Damer
Dongola
Karima
Merowe
Wadi Halfa
Salima Oasis
El 'Atrun
W. Howar
W. el Milk
W. Muqaddam
Abeshe
Geneina
Kutum
El Fasher
Zalingei
Nyala
Bara
El Obeid
En Nahud
Umm Ruwaba
Kosti
Rabak



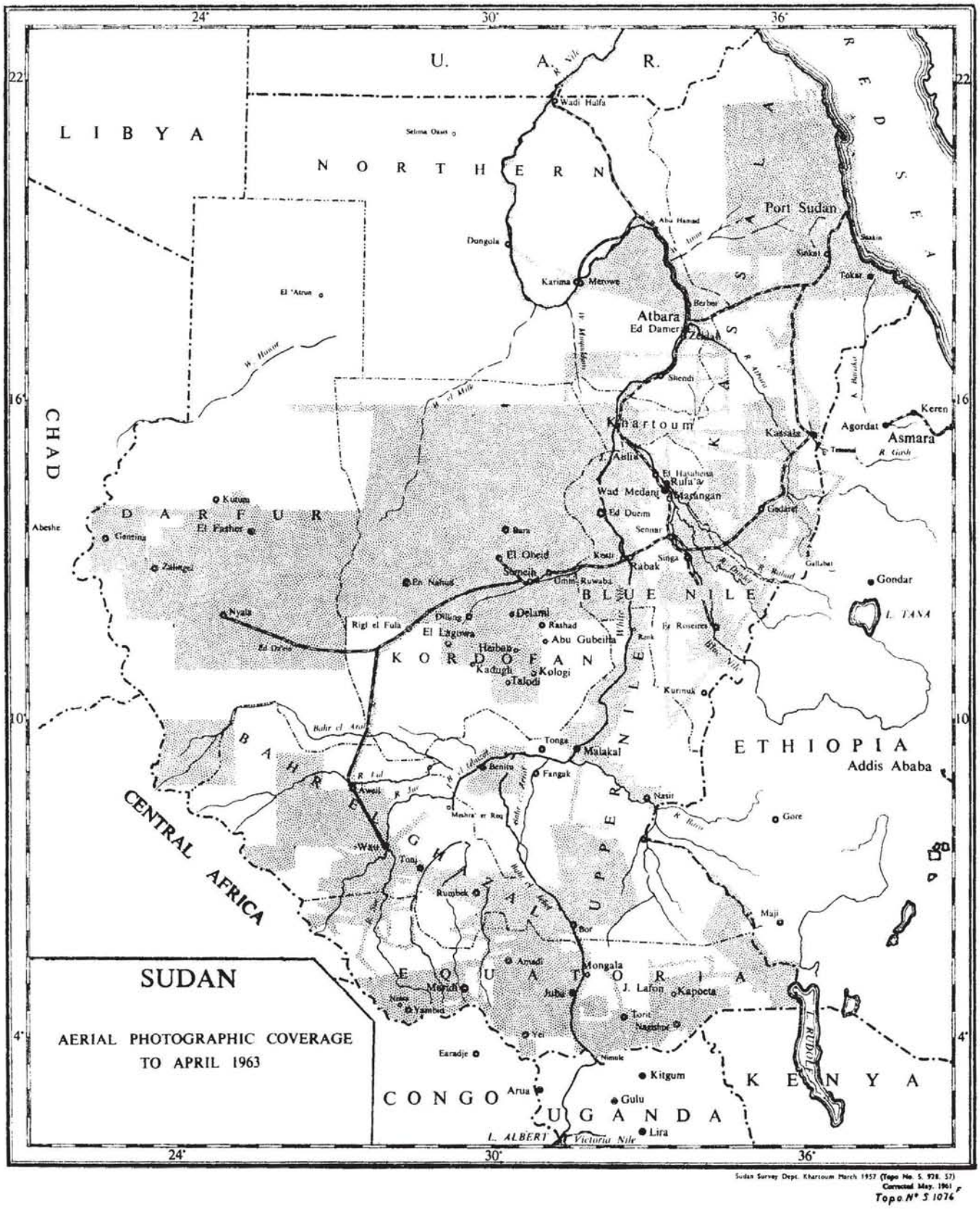
Sudan: index map showing basic topographic mapping



Sudan: index map showing 1:100,000 topographic mapping



Sudan: large scale topographic mapping



Sudan: aerial photographic coverage

trolled by theodolite and tape traverses. These plans are used for preliminary registration, settlement and replanning schemes. After replanning schemes have been executed the survey of individual plots is carried out by chain for the purpose of working out exact areas for final settlement and registration.

Programme for topographical mapping

The above review shows that very little has been achieved in the field of large scale topographical mapping. This is due to shortage in technical field staff and the engagement of this staff on large cadastral surveys for agricultural development. On the other hand, the personnel of the mapping unit is fully engaged on the preparation of mosaics and special small scale maps. A good number of these maps, on scales ranging from 1:2,000,000 to 1:10,000,000 covering natural resources and other statistical information, have been prepared. Steps are now being taken to produce these maps on scale 1:4,000,000 and to publish them in a national atlas.

A rigid programme has been laid down for mapping 40,000 sq.km. north of Khartoum and some 100,000 sq.km. in the Red Sea Hills to be carried out with assistance from USAID. The ground control for the first area was started in April 1963 and work for the second area, will begin in November 1963.

TANGANYIKA TECHNICAL SURVEY SERVICES AND MAPPING PROGRAMME[1]

Organization

The Tanganyika Survey Division falls within the portfolio of the Minister for Lands, Forests and Wildlife. The Division is headed by a Commissioner who is responsible for national mapping services, cadastral surveys and geodetic work. These responsibilities are shared in two branches of the Division, the "Cadastral and Geodetic Branch" and the "Topographic and Reproduction Branch", each headed by an assistant commissioner.

Mapping and cartography

The basic national mapping scale is 1:50,000. This series is prepared from aerial photographs and the major portion of the task has been carried out by the UK Directorate of Overseas Surveys who are still continuing operations on a large scale in Tanganyika under technical assistance agreements.

Other national series are 1:250,000 and district series. The 1:250,000 series is a new series to a specification adopted by the East African countries; it is replacing a 1:125,000 series for which cover for just over 1/3rd of the country is available. These 1:125,000 sheets were prepared largely from plane table surveys.

The district maps are an uncontoured low cost series which provide a considerable amount of useful data and have proved extremely popular. The entire country is covered by District sheets.

Full national cover is provided at 1:500,000 on 25 sheets. These maps were prepared by military forces in 1942-1943 and although about half have been revised the series is becoming outdated.

Tanganyika is also covered on 6 sheets of the *International Map of the World on the Millionth Scale*. A new set of these maps drawn to the new specifications agreed in Bonn in 1962 are in the hand of the Directorate of Overseas Surveys also coming under a technical assistance scheme.

The largest scale at which Tanganyika can be covered on one sheet is 1/2 million. Several versions of topographical maps on this scale are available as well as an annually produced road map.

The Tanganyika atlas is prepared on 1/3 million and comprises 29 pages of maps and diagrams faced by descriptive notes. The atlas contains sections on physical geography, human geography, industry and commerce, town plans, statistics and a gazetteer.

Specific maps on a 1/2 million or 1/3 million base map are also produced for specific purposes, such as illustrating game reserves, etc. Separate atlas pages are also available. All the major towns are now covered on a scale of 1:2,500 or 1:5,000. This involves a large number of sheets in some cases. The township maps are compiled from aerial photography supplied by Tanganyika Government aircraft. Kelsh Plotters are used for the photogrammetric plotting. A Wild A7 is also used to keep ground control to a minimum.

Other special photogrammetric work is carried out, for example, in the preparations of plans for agricultural, engineering and town planning projects.

Cartographic problems

The biggest problem is the vast size of Tanganyika (361,800 square miles) and the relatively small staff available for cartographic work. It proves difficult to keep publications up to date and miscellaneous tasks draw off a certain number of draughtsmen. There are many projects which the Division would like to put in hand, e.g. a new edition of the atlas but limitations must be observed, although staff increases and staff training are gradually making improvement in capacity.

Accommodation is another major difficulty, particularly in printing and reproduction. Overcrowded, unsuitable accommodation in hot humid conditions makes many processes difficult and, indeed, on occasions impossible. A design for new building to overcome this problem has been prepared.

Mapping programme

The current programme involves extension of the 1:50,000 cover by the DOS in the east and northeast of the

[1] The original text of this paper, submitted by Tanganyika, appeared as document E/CN.14/CART/40.

country: a production rate of 30-40 sheets per year is aimed at. 41 sheets are in hand in the Northwest under contracts placed by the Survey Division.

Following on 1:50,000 cover the 1:250,000 series is to be extended. Revision of existing district maps will continue. Extension of township cover to give more scale variation is to be put in hand and revision of existing township sheets is also planned.

Cadastral survey services

Most of the Division's field survey staff are engaged on cadastral surveys of township and estate leasehold properties, as it is one of the conditions of long-term rights of occupancy in Tanganyika that Government has the right ultimately to insist on survey.

In addition, under the Land Registration Ordinance, grants of freehold title made during the time of the German administration have to be surveyed before the titles can be registered. A recent Government bill under which all freehold titles will be converted to 99-year leaseholds and the introduction of compulsory registration of specified regions may result in a heavy demand for cadastral surveys of those old freehold properties which have not yet been surveyed.

The survey staff engaged on cadastral surveys are distributed throughout the country in regional and district survey offices. The majority of these offices are at present under the control of professional expatriate surveyors, each with a staff of junior technical officers who are Africans. Some of the district survey officers are run by African assistant surveyors or survey assistants who have been recruited and trained by the Survey Division.

An increasing number of field survey offices will be run by African surveyors as they qualify for promotion to these posts under the Division's training and Africanization policy. The chief problem in implementing this policy at present is the difficulty of attracting Africans with suitable educational qualifications for training as surveyors.

In addition to their cadastral survey duties, regional and district surveyors and their junior staff undertake various topographical tasks in connexion with the Division's mapping programme.

Geodetic surveys

The geodetic survey activities of the Survey Division has been limited during recent years to geodetic levelling. A network of levelling circuits has been planned to cover the whole of the territory. Up to the end of March, 1963, approximately 1,100 miles of this geodetic levelling had been completed. Some of it has been carried out by the Division's survey staff but the majority has been undertaken by contracts placed with firms of private licensed surveyors, using funds provided under the Government's Three-Year Development Programme. It is difficult to estimate when the planned network of geodetic levelling will be completed. Even if expenditure on this work could continue at the present rate, it would take at least 14 to 15 years.

No primary triangulation network extensions have been undertaken by the Division during the post war period. The network has, however, been extended during this period by the Directorate of Overseas during the course of their field work for the 1:50,000 mapping programme.

Training

Training is regarded by the Division as a top priority task and several training schemes, which have been favourably commented by visiting commissions, have been developed over the past years. Professional training is carried out either by specialized post graduate courses in Britain or by professional studies at the Royal College, Nairobi. Competition for recruits in the technological fields is severe all over the world and particularly so in the developing countries. Consequently difficulty is experienced in obtaining sufficient recruits of the high academic and physical standard required of professional surveyors.

Technical field staff are trained initially at the Survey Training Centre, Dar-es-Salaam, where a one year intensive course is conducted. This is followed by two years practical tuition under the guidance of senior officers in the field. Advanced courses are run at the Training Centre to enable technicians to qualify for senior technical posts. Opportunities are also available to technicians who can obtain the necessary qualifications to proceed with professional training.

Draughting staff are trained in a six months pre-service course which covers cartographic draughting theory and basic practical drawing. Thereafter practical production training continues until draughtsmen are able to carry out advanced techniques. Supervisory staff are trained by Directorate of Overseas Surveys in Britain where modern methods and techniques, for which little local training opportunities occur, are learnt.

Photogrammetric operators are trained initially by the Division's own unit. Trainees who show the necessary aptitudes and possess the necessary academic qualification are sent to the International Training Centre at Delft, Holland, for full time instruction.

Photolithographic staff are instructed by long tested works training schemes. Some supervisory staff have been sent for further training to Britain and Germany.

REPORT ON CARTOGRAPHIC WORK IN TUNISIA[1]

AERIAL PHOTOGRAPHY

Tunisia possesses a complete photo library. Between 1948 and 1954, the whole territory was photographed on the scale 1:20,000 for the northern part of the country, and with fewer details, on the scale 1:50,000 for the south. This aerial cover was made for various development works and for cartographic plotting.

In view of the rapid development of the topographical configuration of regions of fast economic growth and of the progress made in aerial photography (the former cover being made with a camera of 13 × 8 plates equipped with Périgraphe F 150 (lenses) the Secrétariat d'État aux travaux publics et à l'habitat (Secretariat of State for Public Works and Housing) decided to make a new aerial cover.

The Service topographique was instructed to undertake a new aerial coverage of the territory bearing in mind the needs of all Government services as regards topographical charts and photographic interpretation.

The Service topographique is also responsible for the preservation and management of the photo library.

In March 1962 the Secrétariat d'État aux travaux publics et à l'habitat and the Institut géographique national (National Geographical Institute) signed an agreement for a regular aerial coverage of the territory of the Republic. Under this agreement provision is made for:

(1) Panchromatic photographing on glass plates of the whole country on the scale 1:25,000;

(2) Coverage of the whole territory on infra-red film on the scale 1:25,0000;

(3) A special coverage on plates and panchromatic emulsion on the following scales:

1:12,500 with Aquilon F.125 lens and size 19 × 19 with a view to plotting large scale topographical charts;

1:7,000 for towns and densely populated regions with Orthor F.210 and F.300 lenses;

1:15,000 for certain flat regions with a view to rectification with an Orthor F.210 lens.

A large part of the special cover has already been made. The original negative plates together with the transparency prints are filed in the photo library of the Service topographique.

The following are the characteristics of this photographing:

Camera tilt within less than 3 degrees;

Overlap between succeeding plates 55 per cent;

Overlap between strips 10 per cent.

PHOTOGRAMMETRY

The Service topographique undertakes stereophotogrammetric plotting in order to obtain topographical charts on the scales 1:20,000 and 1:10,000 covering large areas for the study of preliminary plans for drainage, hydraulic works and development.

The Service topographique is equipped with two Poivilliers Type BP stereographs and one photogoniometer for the matching of plotting cameras. The two plotting instruments are equipped either for plotting 18 × 18 plates taken with Aquilor F.125 lenses, or for plotting 13 × 18 plates (Périgraphe F.150 lenses).

The relative orientation of the plates is effected either by the Von Gruber method or by the Poivilliers (graphic) method.

In addition, the Service topographique has at its disposal a Zeiss SEGV rectifier for carrying out certain work, such as detailed charts of collective lands.

After June 1963, the Service topographique will have at its disposal a C8 stereoplanigraph equipped with an "Ecomat" electromagnetic co-ordinate recorder. This instrument is intended in the first place to be used in carrying out aerial triangulation work.

Preparation of control points

So far aerial triangulation has not been used in the preparation of control points, even though the plotting is done on the scale 1:20,000 the preparation of control points has always been obtained by stereopreparation on the ground. The control points are directly connected by transfer of the points of the general triangulation (4th or 5th order).

GEOGRAPHIC MAPS

The general maps which cover, or should cover, the whole Tunisian territory, are on the following scales:

1:50,000; 1:100,000t 1:200,000.

The maps on the scale 1:200,000 are compiled from maps on the scale 1:50,000, maps on the scale 1:100,000 or from semi-regular surveys. 46 rectangular 30 × 80 cm. (60 × 96 km) sheets covering the whole territory have been prepared and published in 5 colours and shading to accentuate the relief (contours every 50 m) by the French Institut géographique national.

Maps on the scale 1:100,000: compiled and published by the IGN in 6 colours and shading to accentuate the relief, are derived from direct surveys on the scale 1:80,000 with equidistant 25 m. contours.

The 92 existing sheets are rectangular and 30 × 48 cm (30 × 48 km).

Map of Tunisia on the scale 1:50,000: the Institut géographique national compiled 122 sheets of this map by direct surveys and the last 16 sheets by aerial stereographic surveys completed on the ground.

The 130 existing sheets cover the most developed regions of the country, from the north to the Gafsa parallel.

The sheets are designated by their name, by a number taken from a make-up table and are rectangular and 40 × 60 cm (20 × 32 km. on the ground).

So far the IGN has been responsible for publication, which is of two different types:

The type known as "Algeria-Tunesia" holds seven colours and contour relief accentuated by shading;

[1] The original text of this paper, submitted by Tunisia, appeared as document E/CN.14/CART/46.

The type known as "1922" holds five colours and relief emphasized by shading.

Projection of the map on the scale 1:50,000

Clarke ellipsoid (1880).

Bonne projection (origin Paris meridian, parallel 39 grads North, used until 1942).

Lambert conformal conic projection (2 areas) used from the beginning of the Lambert projection.

North Tunisian zone:

40 grads North
11 grads East of Greenwich.

South Tunisian zone:

37 grads North
11 grads East of Greenwich.

All altitudes are reduced to the average level of the Mediterranean Sea at la Goulette.

Maps published by the Topographical Service

As and when stocks of sheet reproductions are exhausted the Service topographique intends to acquire elements for the reproduction of the map on the scale 1:50,000.

TheService topographique already has some sets. The sheets republished by the Service topographique's printing service are of the 1922 type, i.e., printed in four colours, with shading accentuating the relief. They will be revised as and when the need arises.

The Service topographique also prepares in its mapping section and reproduces in its own reproduction workshops various special maps in Arabic or in French, such as the administrative map of Tunisia on the scale 1:500,000, the road classification map, and the like, for the administrative services.

General precision levelling of Tunisia

I. *History*

One of the conditions essential to the preparation of a correct ordnance survey or topographical map is the existence of a homogeneous and well maintained precision levelling network.

It was this fact which, in 1887, induced the Tunisian Government to decide to set up throughout the country a precise levelling network with large links.

The first levelled section was the Tunis-Ghardimaou-Algiers railway track (1887-1889). The ground work was then interrupted and was not resumed until 1903. It continued sporadically until 1909. Between that data and 1913 a total of 2,118 km. of railway track, roads and paths was levelled (see attached map).

The instrument used for this work was the Berthélémy reversible level; until 1911 the levelling rods were fitted with bi-metallic adjustment and since then with the INVAR metal adjustment system.

The marks used were brackets embedded in the vertical dividing-walls of public buildings or bridges and benchmarks placed vertically on horizontal surfaces (bridges or kilometric stones). The average density of these marks was 1 bracket and 2 benchmarks for every 2 km of traversing.

Each team consisted of one reader and one "leveller" who took it in turns to read and simultaneously make the return journey of each section. Each day the record books were despatched to Algiers where a team of computers was established. This team analysed the books, calculated the gross levelling discrepancies, the maladjustments, and the corrections of levelling rods with the help of an appropriate graph. Nevertheless, no definitive levelling discrepancy was calculated before 1914.

The computations were resumed in 1920. All the documents were taken from Colonne Voirol (near Algiers) to Paris. The definitive calculations were made in accordance with methods applied in the French general levelling, and despite some tight closures, the adjustment was effected by the least square method.

The origin of the altitudes was the cement embedded bracket on the Porte de France in Tunis connected to the mean tide gauge of la Goulette installed in 1889.

When they compared the altitudes of certain marks near the Tuniso-Algerian border the computers realized that several errors had crept into the observations depending upon whether these marks were calculated by the Algerian or Tunisian system.

These discrepancies amounted to 322 mm. in the case of the bracket embedded at Kalaa Djerda and the Bône (Algeria)-Babbouch (Tunisia) liaison closed at 330 mm. for a distance of 60 km.

Even within the Tunisian network some inexplicable mistakes were discovered by partial levellings between marks. It was found on enquiry that in certain sections the ground work had been effected on provisional benchmarks which had subsequently been replaced, without liaison, by brackets.

After assembling the data and making certain control calculations, it was possible to establish that these anomalies were due to:

(1) An error in one of the H or N polygons;

(2) The fact that railway tracks had been levelled almost immediately after they had been put into service, which renders considerable subsidence in the enbankments, bridges and similar conctructions very probable;

(3) The absence of a comprehensive plan and lack of order in the ground operations.

These anomalies became a source of anxiety to authorities of the Service topographique and the Chef des Brigades d'études et du cadastre was instructed to discover the causes of these discrepancies and to correct them if necessary.

After studying the documents held by the Service topographique he decided to go to Paris in order to check personally the computations already made.

Upon his return he submitted a report, on 16 December 1924, in which he recommended that:

(1) Publication of the altitudes should be suspended;

(2) Certain doubtful sections should be re-measured;

(3) Some railway tracks where the subsidence of the embankments and other works was to be feared should be levelled.

The instruments used were the Barthélémy, Sikler and Ott reversible levels, bi-metallic compensating devices, then the Invar device. The marks were built approximately 1,500 metres apart. Each team was composed of two operators, one reader and one "leveller" who performed the "down" at the end of the "up" operations and despatched the record books to the Central Office upon completion of each section and not from day to day.

The former registration numbers of the marks have not been retained and a new numbering classified by roads and railway tracks has been introduced.

The tolerance permitted for the closure of polygons was $5\sqrt{D}$ mm. (D being the development of the polygon in km). This error was spread from mark to mark at first proportionally at $2n$ (n being the number of levelling discrepancies), then proportionally at n.

Orthometric correction was applied only to the main marks. Dynamic correction was never operated.

Following these works, four sections were published in December 1926, then some results were added up to 1929. Since that date no results have been published.

The users soon realized that some sections still presented abnormal discrepancies, in particular the liaison marks with the Algerian network. These marks had different altitudes depending upon whether they were considered as belonging to the Algerian or Tunisian network.

For these reasons no large-scale precision levelling has been carried out since that date and the marks, a good number of which have disappeared, have served only to connect semi-precision levellings.

Confronted with this confused situation, the authorities of the Service topographique decided that the former network was to be completely and systematically re-established and extended to the south and extreme south of the Territory.

II. *New network*

Tunisia's new precision levelling network consists of 11 first order polygons and 11 peripheral zones.

Its total length is 3,039 km. 900. It includes 1,400 monuments and 2,324 benchmarks. Of the 1,400 monuments 330 belong to the former network; they were sought out and incorporated in the new network.

56,441 stations and a 217,516 km run on four vehicles were necessary to carry out the ground work which lasted 3 years, from 15 February 1959 to 28 February 1962.

The calculations of the record books, the placing of the traverses and results were always made as the ground work progressed so as to make it possible for the sections known to be defective to be repaired in time.

Every care was taken to provide this network with the characteristics of a high precision network of international value.

(1) Each section was levelled in both directions, by 2 different teams and at different times.

(2) Absolute equality of range obtained by chaining in order to eliminate systematic errors due to the earth's curvature.

(3) Complete general survey with 2 series of readings on each levelling rod.

(4) The maximum tolerance permitted for discrepancies between the up and the down was fixed at $2n$ (n being the number of levelling discrepancies included in the section). Each time this tolerance was exceeded, the section in question was re-measured.

(5) All the work was performed with the Wild N3 level and with the help of Invar metal levelling rods with banded graduations. The calibration, performed at the IGN in Paris, having revealed wide discrepancies in the graduation of two pairs of levelling rods, corrections were made on the ground by the operators on each reading made on these levelling rods before the computations of the record books.

(6) Every two or three days, the value of the maladjustment of each Wild N3 level in use is determined by the team using it. If this value exceeds 3 d/mm. the apparatus is re-adjusted.

(7) Every week, each team controls the heights of levelling rods according to the same plan of comparison and checks the base of the rods from the same support. The purpose of all these precautions is to discover sudden and accidental changes in the physical condition of the material employed and eliminate, or at least minimize as far as possible, systematic errors.

The controls used in these computation methods are such that it is practically impossible for a fault to pass unnoticed either in the observations on the ground or in the successive totals necessary for the computations of the difference in level between consecutive marks.

The Service topographique has endeavoured to establish a homogeneous network both from the point of view of the distribution and development of polygons and from the point of view of working method.

The distribution of the polygons takes account of the needs of the country in precision levelling in the regions of the south and extreme south, regions in which large-scale industrial and agricultural development is possible. Thus most of the main roads have been levelled.

Road G.P. 1 from Tunis to the Tuniso-Libyan frontier for 589 km.

G.P. 3 from Kairouan to Gafsa, Tozeur and Nefta for 316 km.

G.P. 5 from Tunis to Medjez El Bab, Téboursouk and le Kef for 172 km.

G.P. 7 from Tunis to Mateur, Djalta, Sedjenane and Tabarka for 164 km.

G.P. 8 from Tunis to Bizerta for 65 km.

G.P.12 from Sousse to Maktar and le Kef for 231 km.

G.P.13 from Sfax to Kasserine for 202 km.

G.P.15 from Gabès to Gafsa, Fériana and Thélepte for 224 km.

G.P.17 from Thélepte to Kasserine, Thala, Tadjérouine, le Kef, Souk, El Arba and Tabarka for 256 km.

and some other average communication roads.

In the south-west of the country, where the absence of long distance roads caused the layout of the railways lines

to be followed, 162 km of railways track have been levelled between Medjen Bel Abbès, Henchir Souatir, Tabedit, Métlaoui, Tozeur and Kriz.

The difficulties of access to these sections, where no track exists nearby, made work in the field extremely arduous.

This new network is homogeneous, as far as methods of observation are concerned, which permits far greater precision in the calculations of probable errors, and in the adjustment and distribution of errors in observations.

Furthermore, provision was made for three aerials designed to facilitate, at the appropriate moment, the integration of our network with the North African network, and in particular with the Algerian network.

The aerial of Babbouch near Tabarka will provide the connexion with Bône, that of Haïdra will connect our network with the polygon T, and the aerial of Nefta will connect it with polygon P of the first-order Algerian network. That of Ben Gardane will provide the connexion with the Libyan network.

Before turning to technical results, it is right to recall that the precision of a levelling network is characterized by the tolerance accepted in the closing of the polygons, taken one by one. Account was taken of the recommendations of the Association internationale de géodésie (International Geodesy Association), which classifies high precision levelling as that where the characteristic coefficient T—that is to say, the probable accidental limit value per kilometre of the total error does not exceed *two millimetres* per kilometre (the definition accepted in 1936 at the Edinburgh International Conference). The tolerance of closing the polygons was fixed at $T\sqrt{L}$ or $2\sqrt{L}$ mm.,

T: being the probable accidental limit value per kilometre of the total error, expressed in millimetres;

L: being the total length of the polygon measured in a homogeneous manner, expressed in kilometres.

First-order polygon—B;

Tunis, Bizerta, Djalta, Mateur, Djedeida, Tunis

The connexion betweenBizerta and Zarzouna across the canal, which is 280 metres wide, was carried out by the method of reciprocal sight lines: 522 sights were taken from each side of the canal by two different operators. In view of the relatively short distance separating the two banks, Invar levelling rods were used with success. This method allowed the polygon to be closed.

Number of monuments established and measured		145
Number of cemented benchmarks measured		100
Number of stations:		
In both directions	2,839	
Retakes of defective sections, say 24%	684	
TOTAL	3,523	
Total length of sides of polygon		183.544 km.
Total of positive levelling discrepancies		+599.9624 m.
Total of negative levelling discrepancies		−599.9518 m.
Gross closing deviation		+0.0106
Difference of the orthometric corrections		−0.0010
Closure		+0.0096

Tolerance $2\sqrt{184} = 0.0280$ m.

First-order polygon—D:

Bordj-Cedria, Soliman, Tazoghrane, Menzel-Temine, Korba, Nabeul, Hammamet, junction route G.P. 1, GROMBALIA and BORDJ-CERDRIA.

Number of monuments established and measured		124
Number of cemented benchmarks measured		122
Number of stations:		
In both directions	2,642	
Retakes of defective sections, say 11%	282	
TOTAL	2,929	
Total length of sides of polygon		180.716 km.
Total of positive levelling discrepancies		+637.0971 m.
Total of positive orthometric corrections		+0.0018 m.
TOTAL		+637.0989 m.
Total of negative levelling discrepancies		−637.1074 m.
Total of negative orthometric corrections		−0.0009 m.
TOTAL		−637.1083 m.
Closure		−637.1083 m.
		+637.0989 m.
		−0.0094 m.

Tolerance 2 mm. $\sqrt{181} = 2$ mm. $\times 13.5 = 0.0270$ m.

First-order polygon—E:

Tunis, Medjez-El-Bab, Teboursouk, junction route G.P. 5—G.P. 12, Souk-El-Arba, Ain-Draham, Tabarka, Sedjenane, Mateur, Djedeida, Tunis

Number of monuments established and measured		205
Number of cemented benchmarks measured		400
Number of stations:		
In both directions 7,291 / Retakes of defective sections, say 20% 1,443	8,734	
Total length of sides of polygon		435.710 km.
Total of positive levelling discrepancies		+2986.1346 m.
Total of positive orthometric corrections		0.0216 m.
TOTAL		+2986.1562 m.
Total of negative levelling discrepancies		−2986.1433
Total of negative orthometric corrections		−0.0124
		−2986.1557
Closure		−2986.1557 m.
		+2986.1562 m.
		−0.0005 m.

Tolerance: 2 mm. $\sqrt{436} = 2 \times 21$ mm. $= 0.0420$ m.

First-order polygon—G:

Tunis, Sousse, M'Saken, Kairouan, crossroads G.P. 3—G.P. 12, Haffouz, Maktar, crossroads G.P. 12—G.P. 5, Téboursouk, Medjez-El-Bab, and Tunis

Number of monuments established and measured		220
Number of cemented benchmarks measured		505
Number of stations:		
In both directions 8,560 / Retakes of defective sections, say 34% 2,904	11,464	
Total length of sides of polygon		533.753 km.
Total of positive levelling discrepancies		+2637.0600 m.
Total of positive orthometric corrections		+0.0029 m.
TOTAL		+2637.0629 m.

Total of negative levelling discrepancies .	−2637.0047 m.
Total of negative orthometric corrections .	−0.0417 m.
TOTAL	−2637.0464 m.
Closure	+2637.0629 m.
	−2637.0464 m.
	+0.0165 m.
Tolerance: 2 mm. $\sqrt{534}$ = 2 mm. × 23.	0.0460 m.

First-order polygon—I:
Sbeitla, Kasserine, Thala, Kalaa-Djerda, Tadjerouine, Le Kef, junction G.P. 5—M.C. 78, Maktar, Haffouz, junction G.P. 3—G.P. 12, Fondouk-El-Haouareb, Hadjeb-El-Aioun, Sbeitla

Number of monuments established and measured.		176
Number of cemented benchmarks measured		344
Number of stations:		
In both directions . . . 6,960		
Retakes of defective sections, say 9% 662	7,622	
Total length of sides of polygon		417.454 km.
Total of positive levelling discrepancies . .		+2799.6540 m.
Total of positive orthometric corrections .		+0.0679 m.
TOTAL		+2799.7219 m.
Total of negative levelling discrepancies . .		−2799.6675 m.
Total of negative orthometric corrections .		−0.0479 m.
TOTAL		−2799.7154 m.
Closure		+2799.7219 m.
		−2799.7154 m.
		+0.0065 m.
Tolerance: 2 mm. $\sqrt{417}$ = 0.0400 m.		

First-order polygon—J:
Sousse, Monastir, Djemmal, Moknine, Mahdia, Ksour-Essaf, La Chebba, Djebeniana, Sfax, El-Djem, M'Saken and Sousse

Number of monuments established and measured.		149
Number of cemented benchmarks measured		275
Number of stations:		
In both directions . . . 4,679		
Retakes of defective sections, say 11% . . . 502	5,181	
Total length of sides of polygon		319.765 km.
Total of positive levelling discrepancies . .		+813.6770 m.
Total of positive orthometric corrections .		+0.0053 m.
TOTAL		+813.6823 m.
Total of negative levelling discrepancies. .		−813.6520 m.
Total of negative orthometric corrections. .		−0.0013 m.
TOTAL		−813.6533 m.
Closure		+813.6823 m.
		−813.6533 m.
		+0.0290 m.
Tolerance: 2 mm. $\sqrt{320}$ = 2 mm. × 18 = 0.0360 m.		

First-order polygon—K:
Sfax, Sbeitla, Kairouan, M'Saken, El Djem, Sfax

Number of monuments established and measured.		194
Number of cemented benchmarks measured		411
Number of stations:		
In both directions . . . 6,654		
Retakes of defective sections, say 15% . . . 995	7,649	
Total length of sides of polygon.		452.362 km.
Total of positive levelling discrepancies. .		+1410.4201 m.
Total of positive orthometric corrections. .		+0.0061 m.
		+1410.4262 m.
Total of negative levelling discrepancies. .		−1410.3716 m.
Total of negative orthometric corrections. .		−0.0213 m.
TOTAL		−1410.3929 m.
Closure		+1410.4262 m.
		−1410.3929 m.
		+0.0333 m.
Tolerance: 2 mm. $\sqrt{452}$ = 2 mm. × 21.28 = 0.0430 m.		

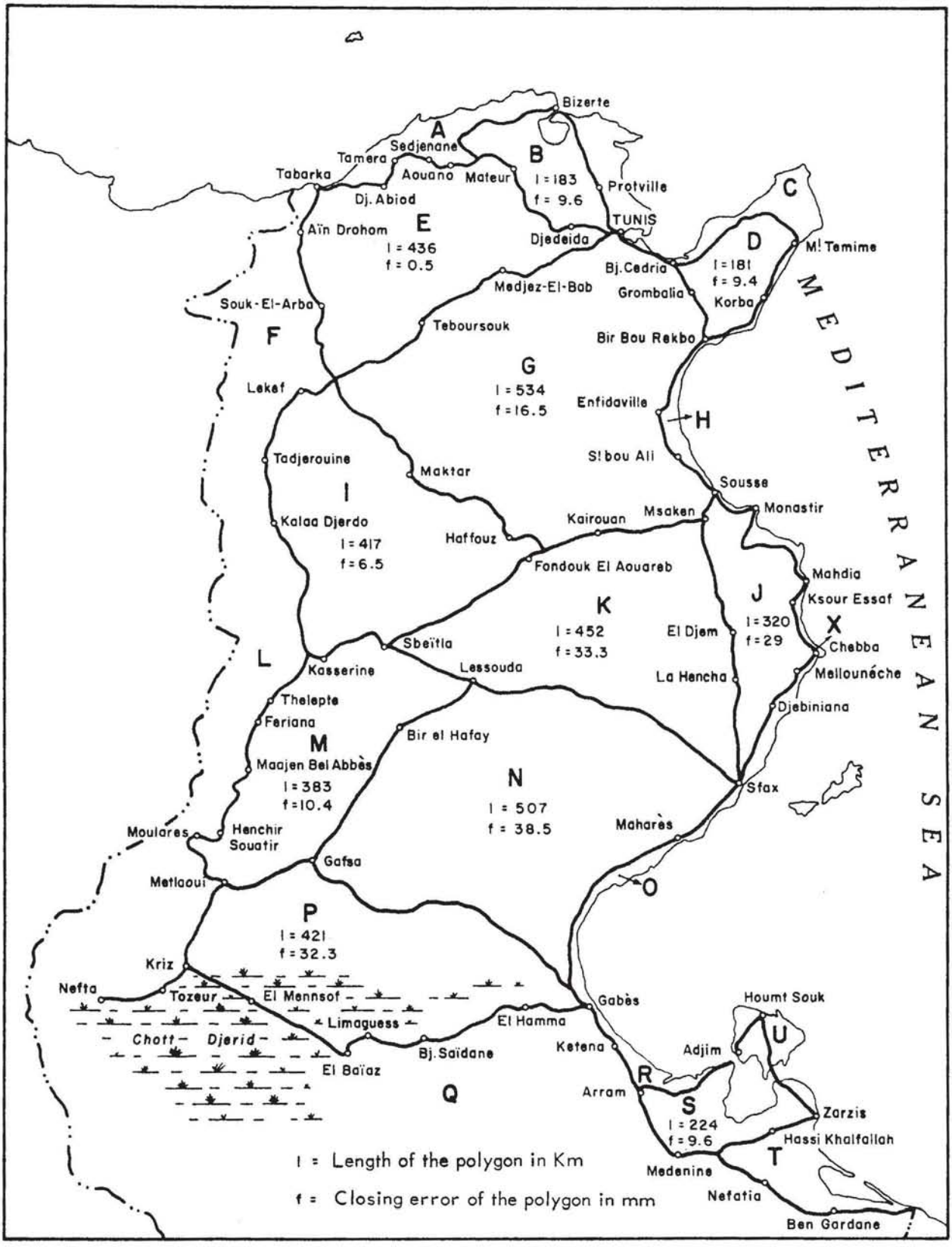
Polygon M:
Kasserine, Thelepte, Madjen-Bel-Abbes, Henchir-Souatir, Tabedit, Metlaoui, Gafsa, Bir-El-Hafey, Lessouda, Sbeitla, Kasserine

Number of monuments established and measured.		129
Number of cemented benchmarks measured		323
Number of stations:		
In both directions . . . 5,731		
Retakes of defective sections, say 7% . . . 380	6,111	
Total length of sides of polygon.		382,834 km.
Total of positive levelling discrepancies. . .		+1149.4925 m.
Total of positive orthometric corrections. .		+0.0506 m.
		+1149.5431 m.
Total of negative levelling discrepancies. .		−1149.5005 m.
Total of negative orthometric corrections .		−0.0322 m.
		−1149.5327 m.
Closure		+1149.5431 m.
		−1149.5327 m.
		+0.0104 m.
Tolerance: 2 mm. $\sqrt{382}$ = 0.0380 m.		

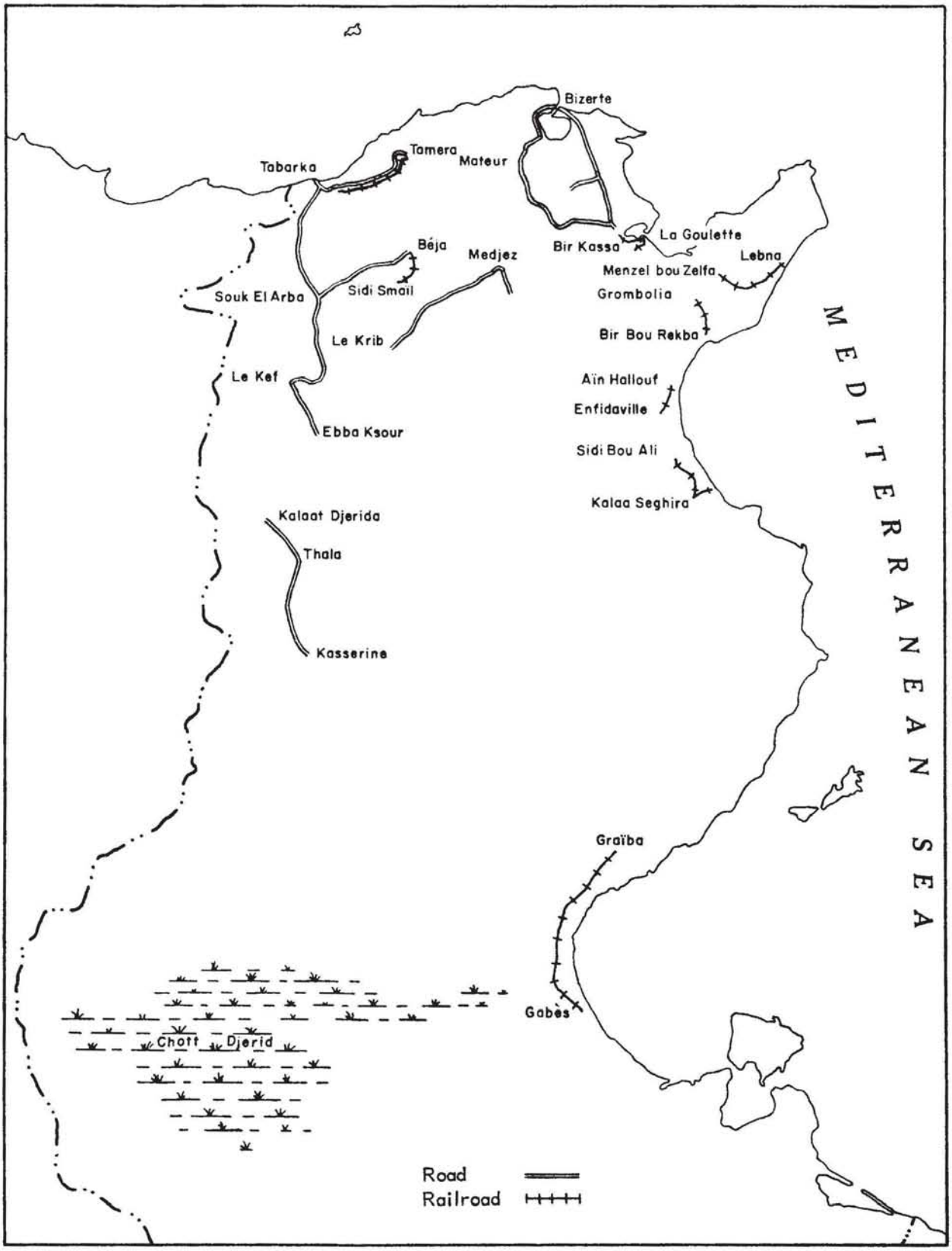
Polygon N:
Sfax, La Skhira, El Aouinet, Gafsa, Bir-El-Hafey, Sidi Bou Zid, Lessouda, Sfax

Number of monuments established and measured.		170
Number of cemented benchmarks measured		484
Number of stations:		
In both directions . . . 7,102		
Retakes of defective sections, say 24% . . . 2,930	10,032	
Total length of sides of polygon.		507.029 km.
Total of positive levelling discrepancies. .		+1171.6046 m.
Total of positive orthometric corrections. .		+0.0064 m.
TOTAL		+1171.6110 m.
Total of negative levelling discrepancies. .		−1171.5432 m.
Total of negative orthometric corrections .		−0.0293 m.
TOTAL		−1171.5725 m.
Closure		+1171.6110 m.
		−1171.5725 m.
		+0.0385 m.
Tolerance: 2 mm. $\sqrt{506}$ = 2 mm. × 22.5 = 0.0450 m.		

TUNISIA - NEW PRECISE LEVELLING NETWORK

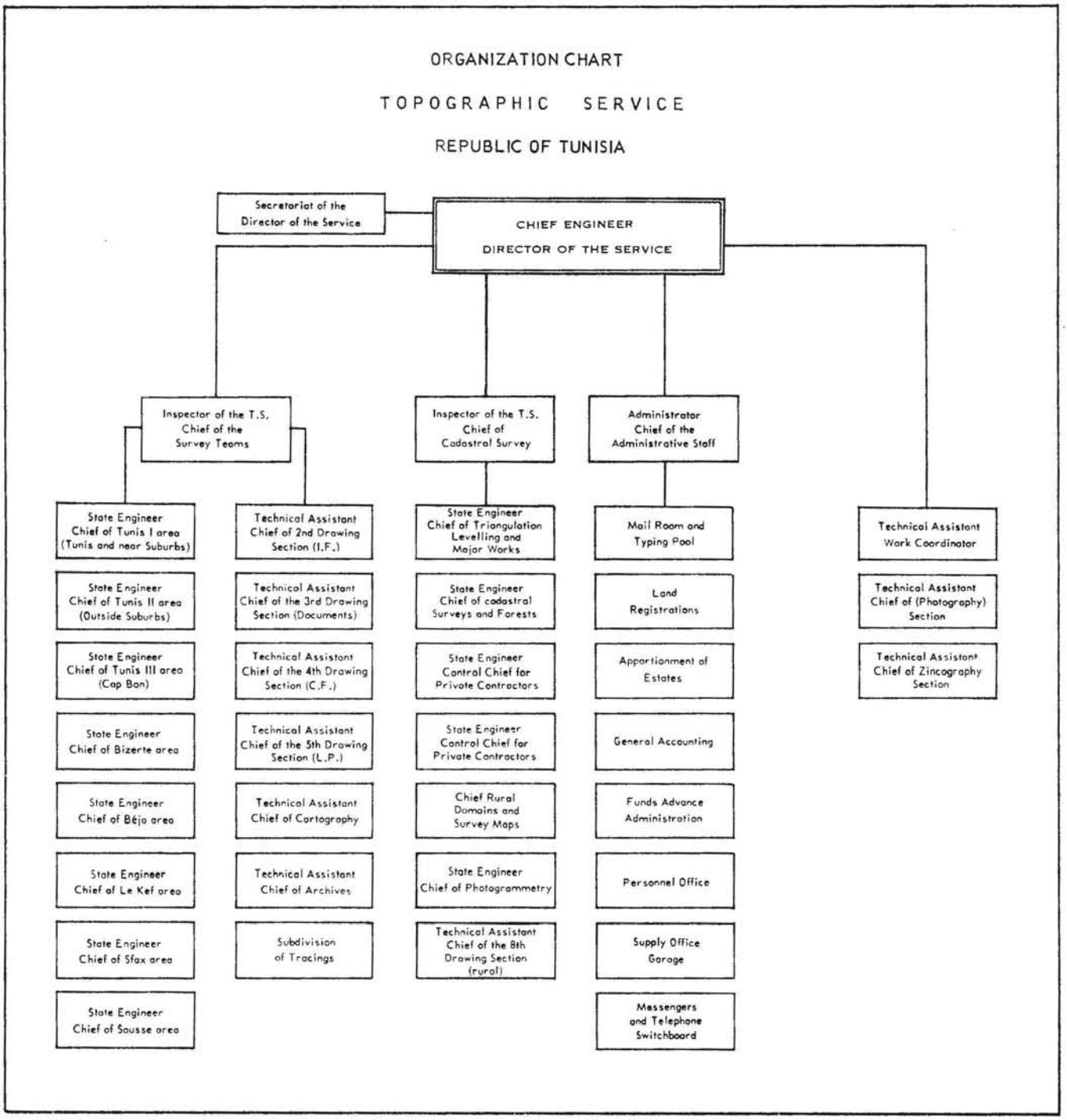


Tunisia: new precise levelling network



Tunisia: precise levelling done between 1924-1929

Tunisia: precise levelling done between 1887-1913



Tunisia : organization chart

Polygon P:

Gabes, El Hamma de Gabes, Kebili, Passage of the Chott El Djerid, Kriz, Metlaoui, Gafsa, Gabes

Number of monuments established and measured		130
Number of cemented benchmarks measured		304
Number of stations:		
In both directions	6,246	
Retakes of defective sections, say 24%	2,634	8,880
Total length of sides of polygon		421.467 km.
Total of positive levelling discrepancies		+1031.1631 m.
Total of positive orthometric corrections		+0.0062 m.
TOTAL		+1031.1693 m.
Total of negative levelling discrepancies		−1031.1287 m.
Total of negative orthometric corrections		−0.0083 m.
TOTAL		−1031.1370 m.
Closure		+1031.1693 m.
		−1031.1370 m.
		+0.0323 m.

Tolerance: 2 mm. $\sqrt{420} = 2$ mm. $\times 205 = 0.0410$ m.

Polygon S:

Medenine, Zarzis, El Kantara, Houmt-Souk, Adjim (Djerba), Djorf, Mareth, Ksar Koutine, Medenine

Establishing the connexion between Adjim and Djorf, across an arm of the sea 2,650 metres wide, was made possible by using the method of reciprocal sight lines. As the distance is considerable, special levelling rods graduated from 20 cm. to 20 cm. were constructed and used.

Seven hundred and seventy-two sights were taken from each side by two operators, one stationed on the mainland and the other on the Customs building of Adjim (Djerba). The average of these 1,544 observations made it possible to obtain a result that was sufficiently precise to close the polygon with the required tolerance.

Number of monuments established and measured		123
Number of cemented benchmarks measured		80
Number of stations:		
In both directions	3,281	
Retakes of defective sections, say 11%	364	3,645
Total length of sides of sides of polygon		+224.382 km.
Total of positive levelling discrepancies		+554.0985 m.
Total of positive orthometric corrections		+0.0021 m.
TOTAL		+554.1006 m.
Total of negative levelling discrepancies		−554.1094 m.
Total of negative orthometric corrections		−0.0008 m.
TOTAL		−554.1102 m.
Closure		−554.1102 m.
		+554.1006 m.
		−0.0096 m.

Tolerance: 2 mm. $\sqrt{224} = 2$ mm. $\times 15 = 0.0300$ m.

Some records to which attention may usefully be drawn

Record for the number of stations carried out in one day	118 stations
Record for the number of kilometres levelled in one day	8.400 km.
Record for work performed in a fortnight	73.850 km. with 1,171 stations
Record for work performed in a month	131.910 km. with 1,986 stations

Cost price per kilometre of precise levelling

Statement of expenditure from 15 February 1959 to 28 February 1962

	Dinars
Emoluments and travel allowances of technicians	9,579,057
Workers and drivers of vehicles	12,451,271
Motor fuel and lubricants	2,285,352
Maintenance costs of vehicles and garaging	922,479
Purchase of rods, monuments, cement, stakes, hardware and ferrules	204,631
TOTAL COSTS	25,442,790

Cost price per kilometre when twice levelled (in both directions)

Office work has reached an advanced stage in calculating the probable errors by section.

Adjustment and publication of heights will be completed by the end of 1963.

REPORT ON CARTOGRAPHIC ACTIVITY IN UGANDA[1]

INTRODUCTION

The Uganda Survey Department was established in 1900. Shortly afterwards the Department became responsible for land matters, and has, at different times also been responsible for mines and town planning. Since 1956 it has been known as the Department of Lands and Surveys and has the following main sections: survey; lands; mailo; titles; valuation.

The resources of the Department have always been largely directed towards cadastral survey and land administration. Apart from a few sheets on 1:250,000 in southern Uganda mapped by the Department and by the British Army prior to the First World War, very little topographical mapping was published before the 1950s. Much ground topography had been done at 1:10,000, 1:25,000 and 1:50,000 scales, but as there was no lithographic plant at that time, it was only available in sunprint form. Since 1950 and with the assistance of the Directorate of Overseas Surveys (D.O.S.) a branch of the British Department of Technical Co-operation, very considerable advances in mapping have been made.

[1] The original text of this paper, submitted by Uganda, appeared as documents E/CN.14/CART/41 and Add.1.

1. Geodetic surveys

(a) primary and secondary triangulation

The major and secondary triangulation established in the first instance for mailo (a form of freehold tenure) cadastral surveys in Buganda and as a framework for the 1:250,000 topographical mapping in southern Uganda was not of a high order, and unsatisfactory by modern standards.

The Primary Retriangulation of Uganda has been completed by the DOS in co-operation with the Department, accepting the geodetic chain along the 30th arc of meridian as datum. No new base lines were established, but the Kitgum base was checked by tellurometer, whilst a number of sides were similarly checked by tellurometer between the Kitgum and Kisumu bases, and azimuth was determined at intervals along this chain.

The secondary, now almost entirely by tellurometer traversing, is nearing completion in Acholi district, which will leave only some 12,000 sq. miles required to complete the whole country.

Tertiary breakdown, mainly by tellurometer, is being done by the Department to meet cadastral and large scale mapping requirements.

Since 1956 all stations have been pillared (previously only ground marks were established) and to date 74 primary, 346 secondary and 235 tertiary stations have been pillared.

(b) primary and secondary levelling

The DOS and the Department are currently undertaking a primary levelling programme:

Phase 1

Circuits round the Lake Kyoga drainage basin. Fundamental bench marks have been established at Tororo and Buteba on the Uganda/Kenya frontier, to which the Kenya primary circuits on the Mombasa datum will be connected in the future. In the north-west connexions will be made to the Survey of Egypt Fundamental Bench Marks at Murchison Falls and Nimule, thus providing a connexion between the Mombasa datum and Alexandria datum.

These circuits total some 1,300 miles of which 800 miles have been observed.

The Department is observing secondary lines to water gauges around Lake Kyoga and along the Nile, but the work has been hampered by the unprecedented high level of the water.

This work will provide the basic level data for the further use and control of Nile waters in Uganda.

Phase 2

Primary and secondary circuits in south-western Uganda. Fundamental Bench Marks have been established at Nsongezi and at Kyaka to which the Tanganyika primary levels will in the future be connected.

These circuits total 600 miles of which 100 miles have been observed.

(c) frontier demarcation and survey

Considerable stretches of Uganda's frontiers are not yet demarcated and surveyed, reliance having at present to be placed on old treaty descriptions, some of which are now difficult to interpret:

The Sudan frontier is undemarcated except for a 30-mile section from Jebel Lonyili to Jebel Urungo which was pillared and surveyed by a joint Uganda/Sudan Survey Party in 1960;

The Congo frontier has a number of undemarcated sections, notably in West Nile district for 100 miles the frontier is described as being the Congo/Nile watershed; leading towers were erected in 1960, at the north-west of Lake Albert to give the direction of the first leg of the boundary in the lake. Uganda hopes that it will be possible to arrange with the Congo for the joint demarcation by means of buoys, of the boundary in Lake Albert off the Semliki delta and in Lake Edward off the mouth of the Ishasha River;

The Rwanda frontier was surveyed in 1911 but between some boundary pillars the boundary was described as following natural features such as ridges and watersheds. In 1962, the Department with the agreement of the Rwanda authorities, who subsequently confirmed at site, pillared and surveyed 45 miles of the frontier, converting irregular sections to a rectilinear boundary;

The Tanganyika frontier was re-opened for 30 miles by a cut through the Malabigambo Forest, in 1958;

The Kenya frontier—in 1959-1960, 180 miles of the Uganda/Kenya frontier along the foot of the Turkana Escarpment was demarcated and surveyed by a joint Uganda/Kenya party.

2. Cadastral survey

Broadly, cadastral survey may be divided into three categories:

(a) Mailo;
(b) Urban and rural leasehold out of public land;
(c) Adjudicated freehold.

There are other tenures, of lesser importance and omitted in this short report.

(a) the buganda "mailo" survey

The Kingdom of Buganda was formally declared a British Protectorate in 1894 and on the 10 March 1900 the Uganda Agreement was signed by Sir Harry Johnston, Her Majesty's Special Commissioner, and by the three Regents of Buganda (Kabaka Daudi Chwa being then a minor) and five other persons, on behalf of the Kabaka, Chiefs and people of Uganda. Clause 15 of the Agreement sets out a land settlement by the terms of which the land of Buganda was to be parcelled out to the Kabaka, Regents, Ssaza Chiefs and other notables, and also to some 1,000 lesser chiefs and private landowners and the three missionary societies, the balance of unclaimed land being reserved to the Crown. All allocations were made in multiples of a square mile; hence the term by which this form of tenure has now come to be known.

To implement this important clause in the Agreement a parcellation survey of Buganda was therefore necessary. The Mailo Survey of Buganda commenced on 4 August 1902 with the measurement of the first baseline for a rapid and rather loose triangulation control, adequate for the job in hand. The boundaries of approved claims were surveyed by Planetable at 1:10,000. At the same time topographical detail was plotted which was later used in 1:250,000 compilation.

The Buganda Mailo Survey was in all probability, the first cadastral survey ever undertaken primarily for the purpose of establishing the ownership of land amongst indigenous Africans. It was prosecuted in the face of considerable difficulties such as repeated epidemics of sleeping sickness; in a country where the cutting of boundary lines through thick bush frequently presented a formidable task; and over a span of years which saw inevitable reductions in staff during World War I and the economic depression of the 1930s. It is not surprising therefore, that the original Mailo Settlement Survey was not completed until 1936 with the survey of claims on the Buvuma Islands in Lake Victoria.

Long before this stage was reached it was evident that the over-all survey task was one far greater than had originally been contemplated. Even by 1905 it was known that the Buganda Lukiko's original allotment lists showed that the claims of 3,700 persons had been approved rather than the 1,000 originally intended; and, as most of these claims were, as initially surveyed, fairly large parcels of land, it followed that, upon the death of each original allottee, a demand for sub-division arose from his successors. Furthermore, the people of Buganda were not slow in grasping the idea, at that time new to them, that land could be bought and sold; and so began the process of breaking up these estates into much smaller parcels generally suitable only for peasant agriculture. To safeguard the interests of the landowners by providing an efficient system of record and a guarantee of their interests in land the Registration of Land Titles Ordinance was enacted in 1908 and, in due course, this was replaced by the more comprehensive Registration of Titles Ordinance 1922, the latter being based upon the Torrens system. Each certificate of title is supported by a certified deed plan.

This work of demarcation and survey of the sub-divisions was formerly regarded as essentially the domain of the licensed profession but it has now long since become obvious that the small group of private surveyors could not cope with the ever increasing volume of work and so the Central Government is at present fielding approximately 100 survey parties engaged upon mailo sub-divisional work alone. Five branch offices handle the day to day business of transactions in mailo land and the recruitment and training of both junior survey staff and titles registry staff (who require special instruction in the complexities pecular to this tenure) have comprised an important part of the departmental effort over the last ten years.

The survey technique remains substantially the same; that is sporadic planetable survey (now at a scale of 1:2,500) within the framework provided by the original estate boundaries, with additional control where necessary. Index plans are maintained at a scale of 1:10,000, 1:5,000 or 1:2,500 as appropriate to the density of sub-division and value of the land in any particular locality. Experiments in methods based upon aerial photography (as practised elsewhere in Uganda) have been hampered by the heavier vegetation cover found in Buganda in those densely populated countries around the shore of Lake Victoria; nor is there any tradition amongst Buganda landowners of hedging or fencing their properties, and dealings in "acres" rather than in physical portions of land inevitably entail ground work. Nevertheless, ways of speeding up this work whilst at the same time maintaining the requisite standard of accuracy are constantly being sought. Although 80,000 titles have so far been registered, there are at present time a vast number of further claims still awaiting survey.

(*b*) URBAN AND RURAL LEASEHOLD OUT OF PUBLIC LAND

For the most part these are rigorous theodolite surveys using the national control framework as datum. In a few instances only, local origins have been accepted for isolated surveys which at the present time do not warrant the expense of connection to the national framework. In high density, single storey, housing areas block corners are precisely fixed and within the block planetable or chain survey methods are used.

The leasehold register contains some 13,000 titles.

(*c*) ADJUDICATED FREEHOLD

In 1958 the Adjudication Rules were introduced which made provision for customary tenure to be confirmed by adjudication and for individual registered freehold titles to be issued. The rules have only been applied to a district with the consent of the district council.

At local government level there has been considerable mistrust of the Central Government's intentions and motives in this matter. Only three districts consented to the application of the rules, and pilot schemes were undertaken in each and only in one of these districts has continued work been possible, Kigezi in the south-west corner of Uganda.

The pilot scheme in Kigezi covered about 70 square miles and experimentally, and with some success, property boundary surveys were surveyed by planetable traversing using identified points taken from photogrammetric machine plots at 1:2,500 as datum. Adjudication committees and surveyors had no powers to rationalize irregular boundaries and over 40,000 corner markstones were emplaced for the 7,000 properties in the area.

Although systematic survey through an area is the most economical, it has the disadvantage that limited survey resources are tied up for long periods in particular localities, and progressive farmers who are anxious to obtain a registered title cannot be accommodated. Having completed the pilot schemes the Department therefore now offers to undertake survey for title anywhere, on an increased scale of fees, subject to an instalment being paid in advance.

3. Topographical mapping

Small scale maps

(a) 1:*50,000 Series*

(The largest scale at which complete coverage of the country is planned)

The series is constructed from airphotography by DOS, mainly by slotted template and multiplex. Air cover, contact scale 1:30,000-1:40,000, has been achieved for practically the whole of Uganda, from 1946-1952 by the R.A.F. and subsequently by air survey companies on contract to DOS. The Department is responsible for field completion, and the maintenance of series after the publication of the first contoured edition.

Agreement has recently been reached between the three East Africa departments and DOS on the specifications for an East Africa 1:50,000 series which modifies each country's series to bring to a common specification.

In Uganda the series will total 304 sheets, of which 148 contoured sheets and 41 uncontoured sheets have been published. The Department of Technical Co-operation has offered aid which should see the publication of the series complete by April 1968.

(b) *1:250,000 East Africa Series*

(1° latitude × 1½° longitude)

The specifications for this layered topographical series were agreed jointly by the East Africa Survey Departments and G.S.G.S.

The Department has published the 15 sheets for which it is responsible and Uganda is now completely covered at this scale. 1:50,000 has been used as source material where available and new editions will be published as new 1:50,000 material becomes available.

(c) 1:*250,000 Uganda. Soils series*

Using the line plates of the topographical series printed faint as a base, soils classifications have been overprinted by 3 plate colour printing 12 sheets out of 17 published.

(d) *1:250,000 Uganda. Vegetation series*

Using the same bases as for the Soils Series vegetation classifications have been overprinted by 3 plate colour printing. 4 sheets out of 17 published.

(e) *1:250,000 Uganda geology*

Printed by the Department in co-operation with the Department of Geological Survey. 8 sheets out of 17 published.

(f) *1:500,000 wall map in 4 sections*

Compiled from the 1:250,000 series, contours are omitted, but layers are added in strong colours, names are bold, and casings wide to achieve clarity as a wall map.

(g) *1:1,000,000 IMW series*

The Uganda sheet is nearing completion and it is estimated that it will be published before the end of June 1963. The sheets cover the whole of Uganda and have been extended to 36° East to include sheet NA.36.

(h) *1:1,000,000* ICAO *aeronautical chart*

The Department is responsible for the maintenance of sheet No. 2909, and published Edition 2 in 1959. It is proposed to prepare Edition 3 using the line plates of the 1:1,000,000 IMW as recommended at the United Nations Regional Cartographic Conference for Asia and the Far East, Tokyo 1958.

Special purpose maps

(*i*) *1:125,000 Queen Elizabeth National Park*

Printed in 7 colours, ornamentation includes sketches of animals found in the park, list of the more common birds, and road mileages.

(j) *1:125,000 Murchison Falls National Park*

A layered map with contours at 200-ft. V.I. An inset at 1:10,000 for anglers shows the fishing pools below the Falls and the recorded Nile perch of 100 lb and over. Ornamentation includes sketches of animals found in the park and a list of the more common or interesting birds.

(k) *1:25,000 Central Ruwenzori*

Constructed by DOS from 1955 air cover, from ground control supplied by the Department. A mountaineer's map covering the high peaks and glaciers. The map is hill shaded and special emphasis is given to rock and rock faces.

(l) *1:25,000 Kampale and environs*

The map includes the City of Kampala, Mengo Municipality and Port Bell.

Large scale maps

(m) *1:2,500 town series*

(The largest scale at which coverage of all urban areas is planned)

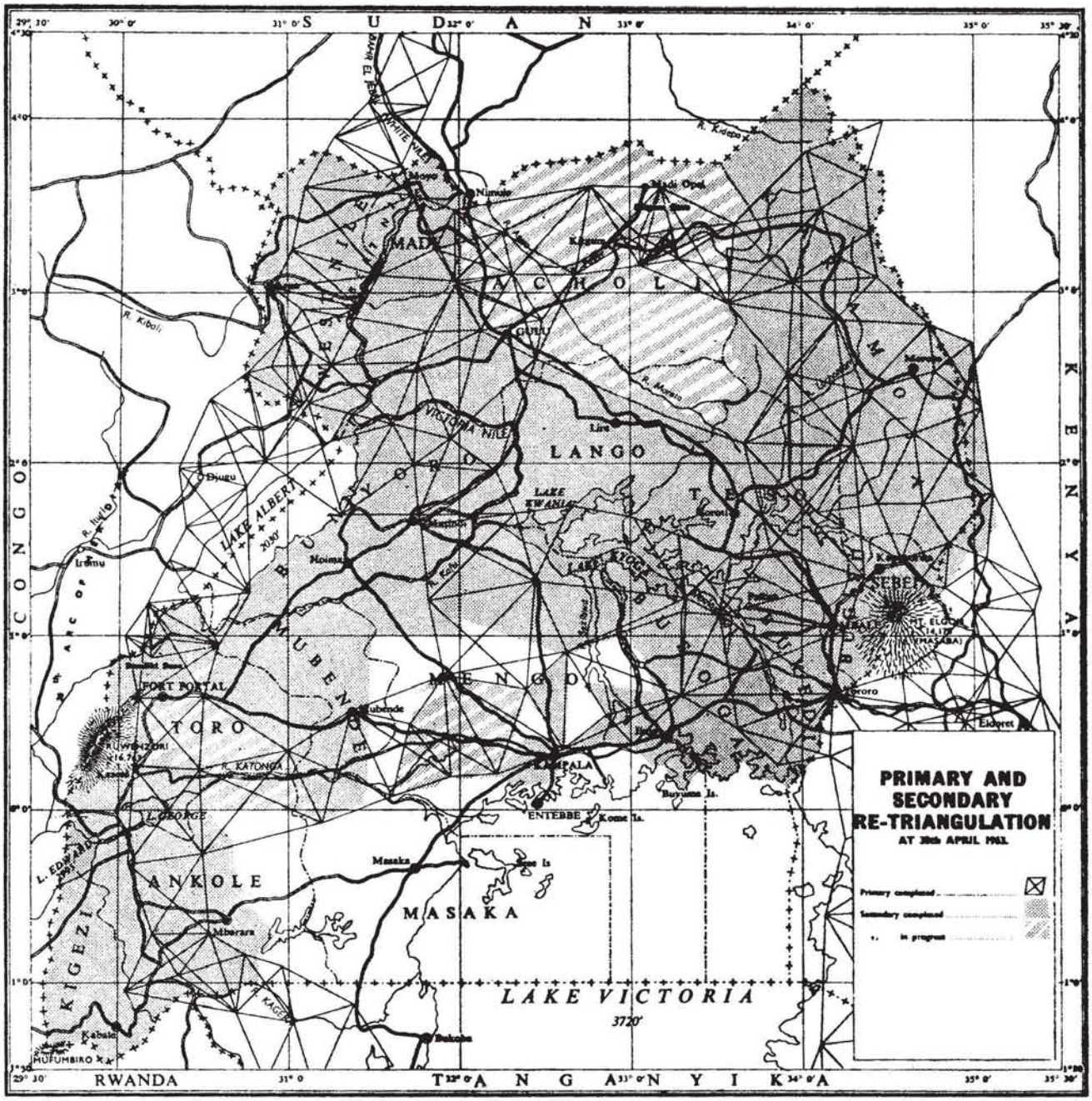
The sheets are constructed photogrammetrically except for single sheet towns which are by ground survey. Sheets covering practically all urban areas have been published in Edition 1 from air photography taken in 1957 onwards.

Revision and maintenance of the larger towns will be done from refly photography, smaller towns by ground survey.

Sheets are published in black, all detail; brown, contours at 5-ft. V.I.; and magenta, cadastral overprint showing property boundaries and plot numbers. A blue water tint is added as necessary. The series will comprise about 330 sheets, of which 273 sheets have been published.

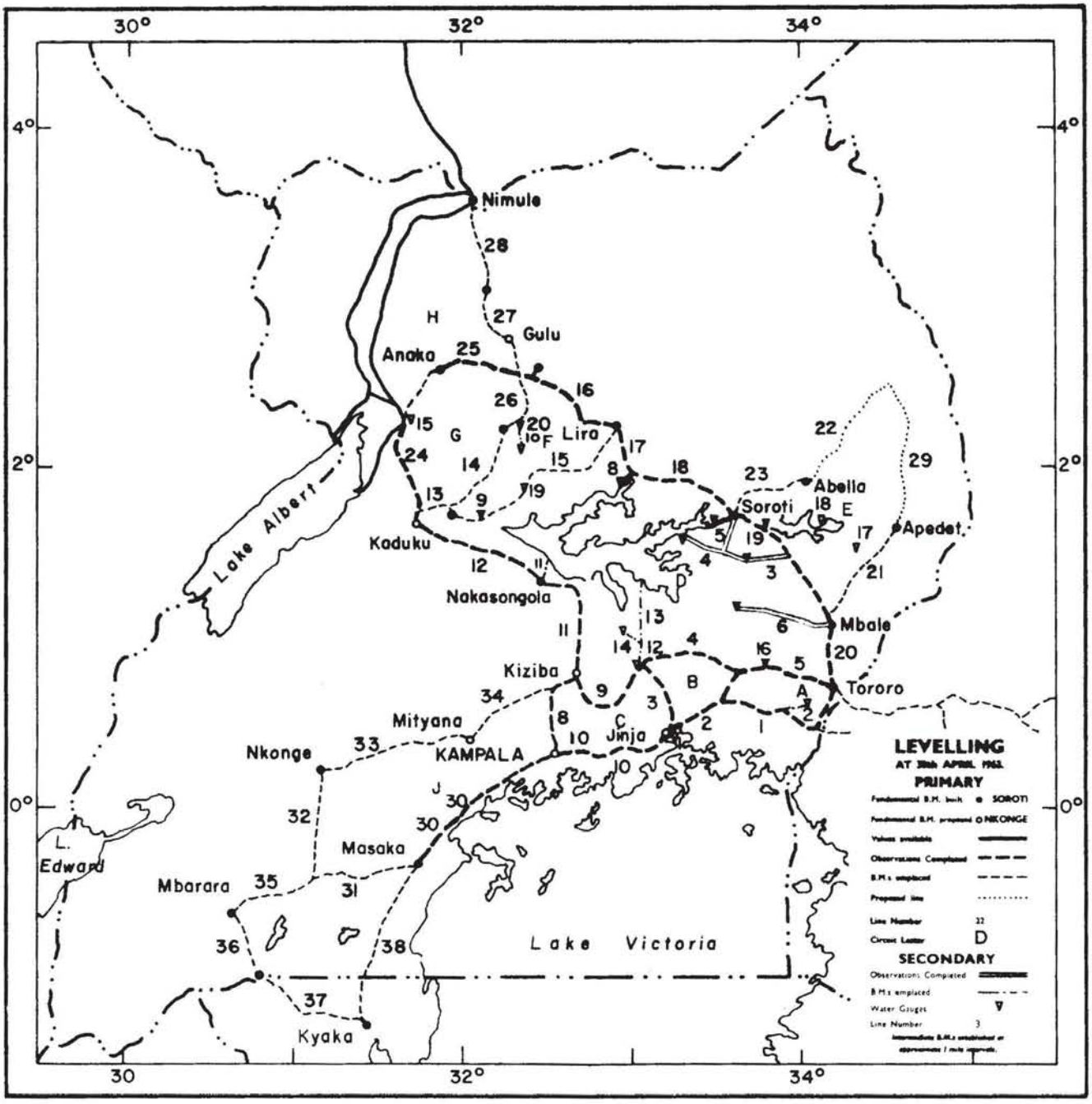
(n) *1:10,000 town series*

Compiled from the 1:2,500 town series. Six colours which include contours at 10-ft. V.I., prominent buildings solid black and named, and all other buildings black cased and filled pink. A gazetteer of roads, streets, and localities is included and the municipal armorial bearings. Kampala and Jinja have been published, whilst Mbale, Tororo, and Masaka are planned.

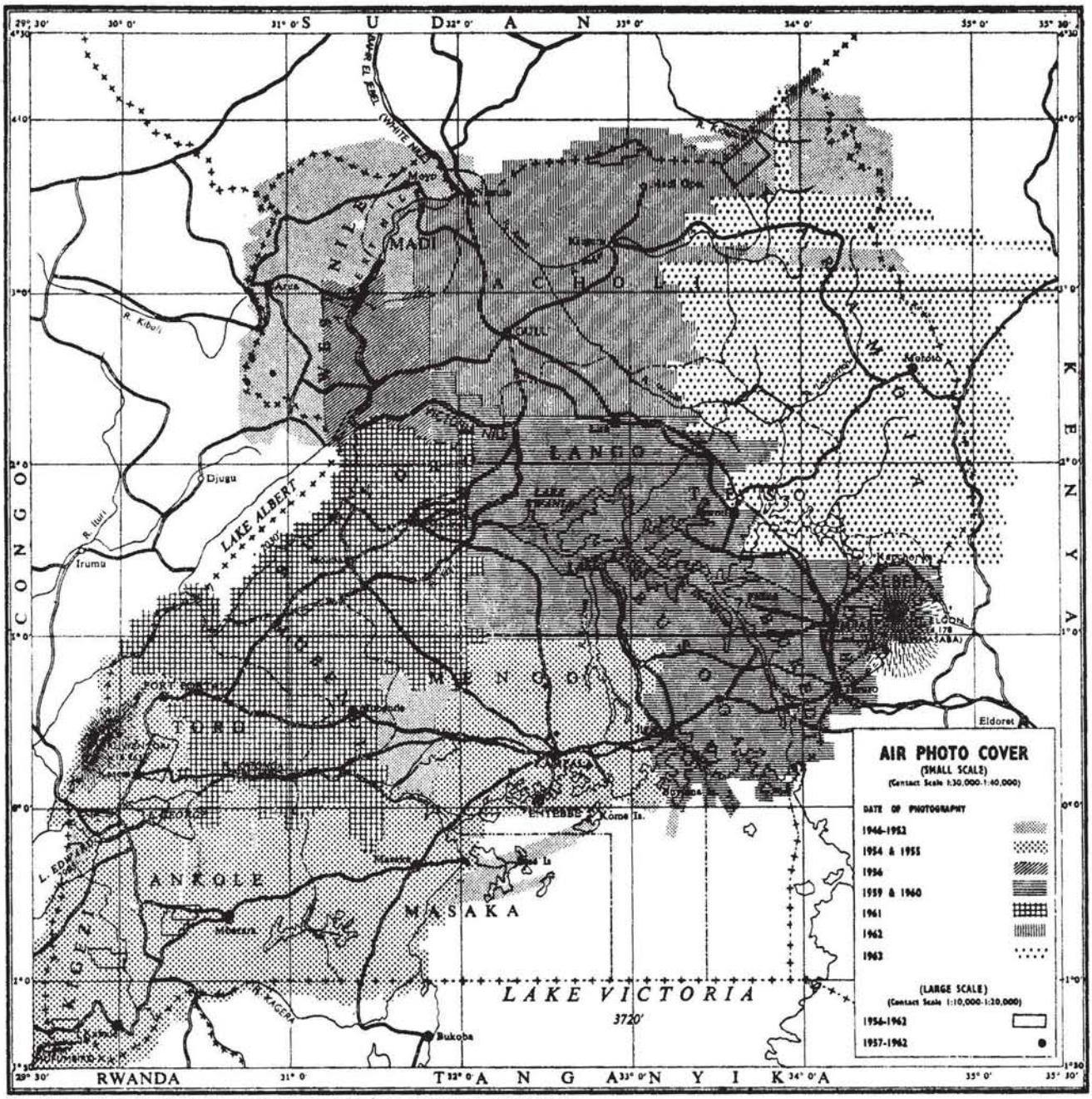


Compiled, drawn and printed by the Department of Lands and Surveys, Uganda, 1963.

Uganda: primary and secondary re-triangulation

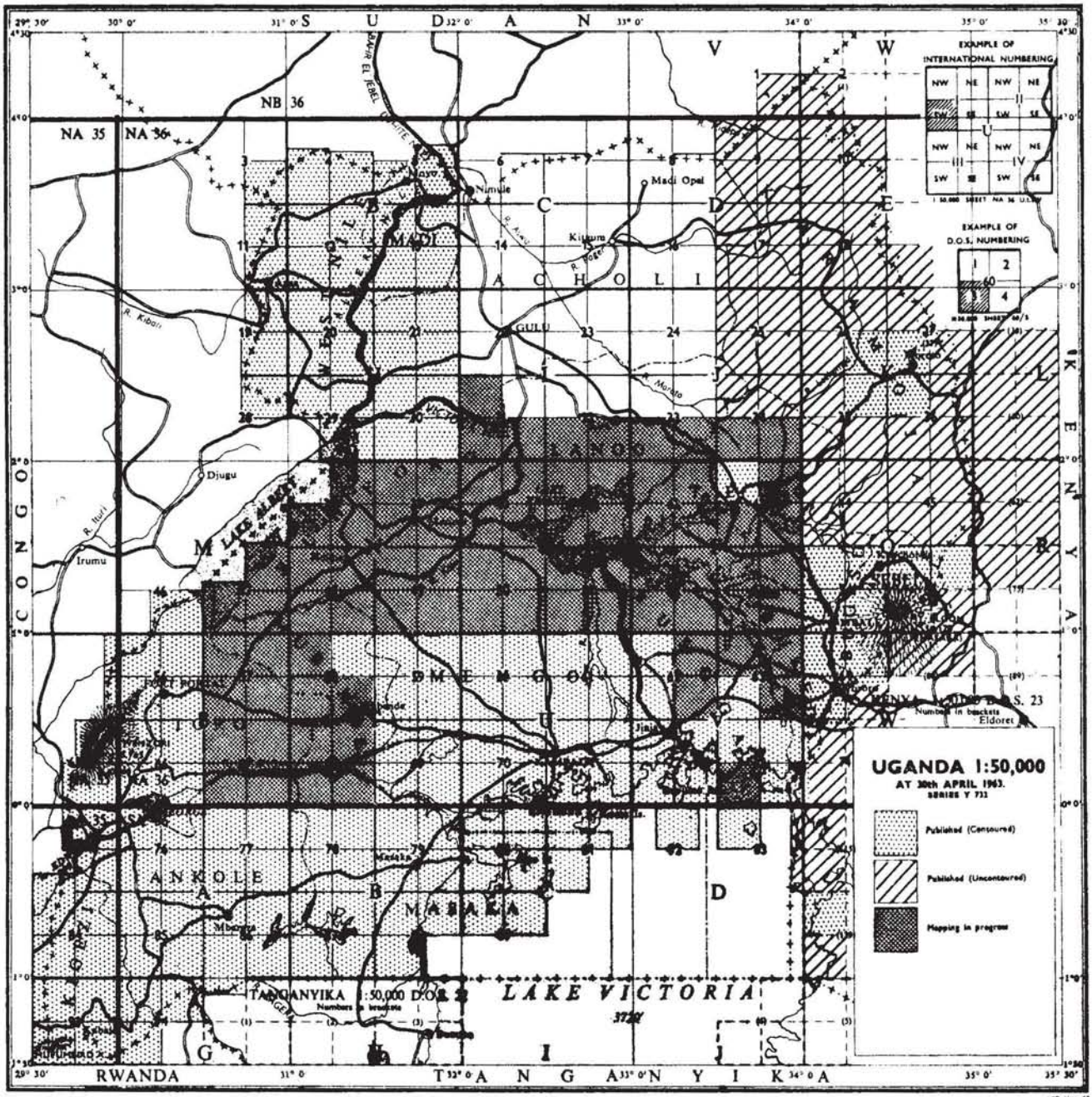


Uganda: levelling



Compiled drawn and printed by the Department of Lands and Surveys, Uganda, 1963.

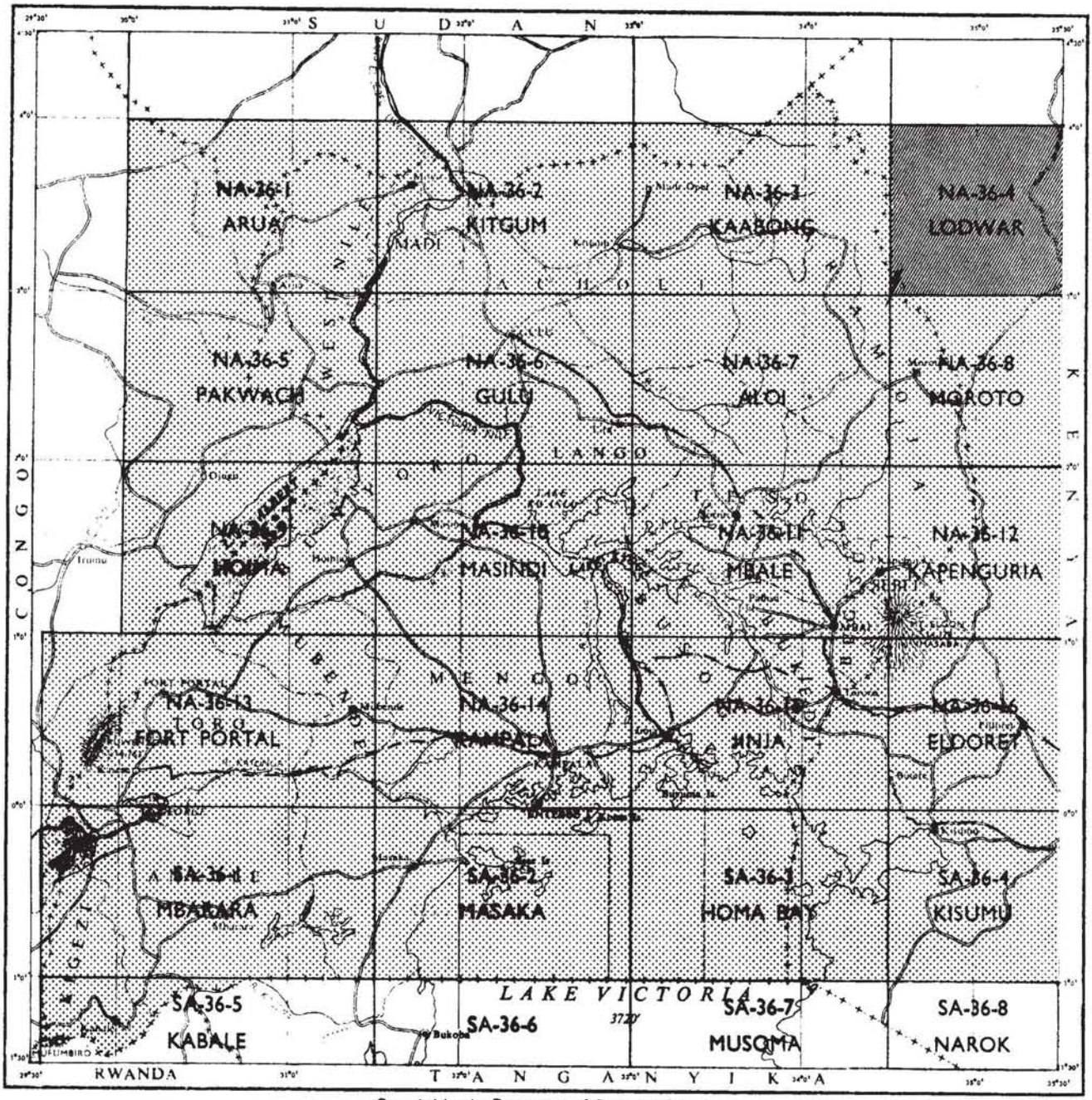
Uganda: air photo cover



Compiled, drawn and printed by the Department of Lands and Surveys, Uganda, 1963.

Uganda: index map 1:50,000

EAST AFRICA 1:250,000 TOPOGRAPHY AT 30th APRIL 1963.

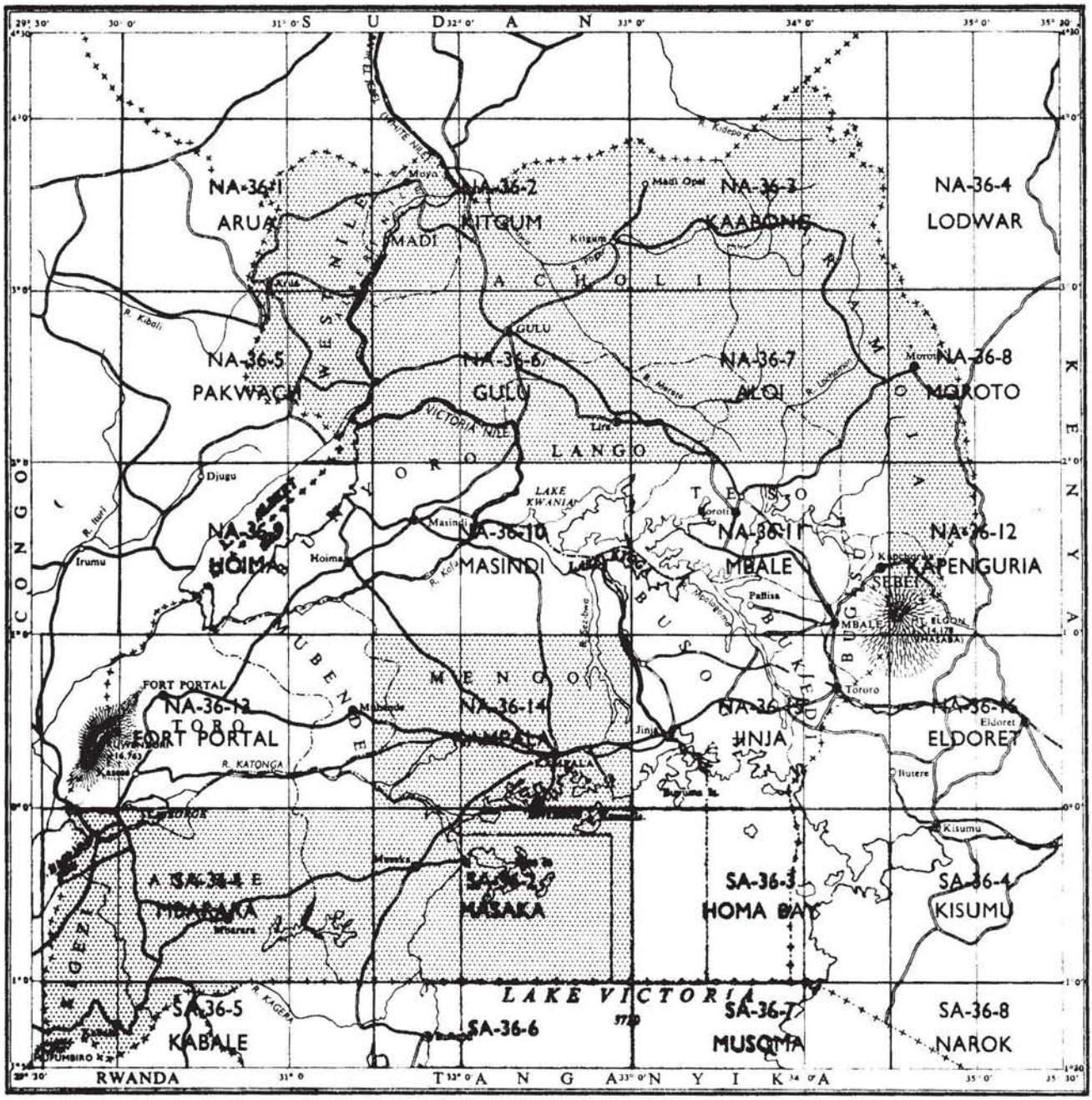


Compiled by the Department of Geological Surveys
Printed by the Department of Lands and Surveys, Uganda.

IN WORK PUBLISHED

Uganda: East Africa 1:250,000 topography

UGANDA 1:250,000 SOILS
AT 30th APRIL 1963.

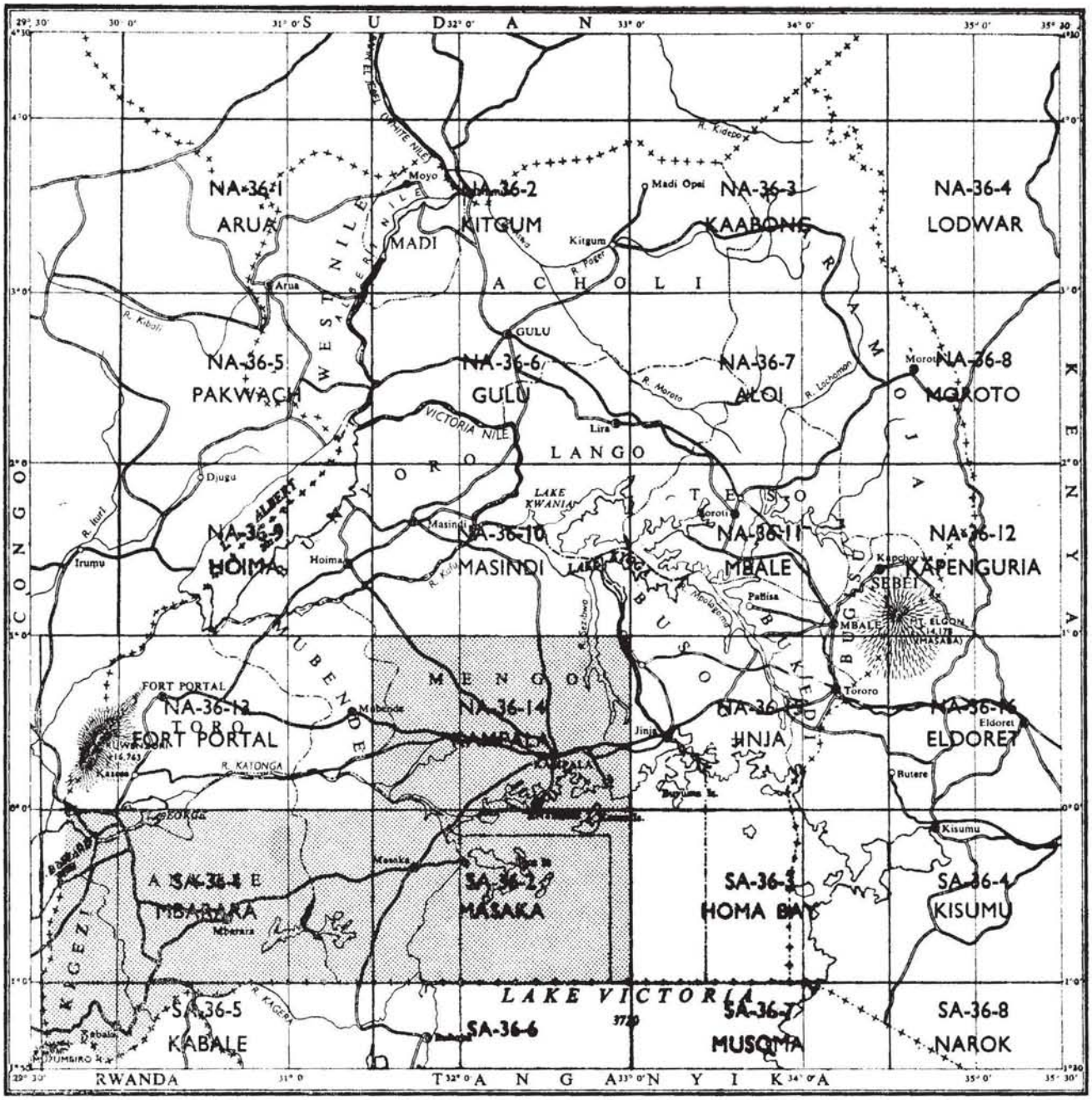


Compiled by the Department of Agriculture.
Drawn and printed by the Department of Lands and Surveys, Uganda.

IN WORK PUBLISHED

Uganda: index map soils 1:250,000

UGANDA 1:250,000 VEGETATION AT 30th APRIL 1963.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SEBEI
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KAMPALA
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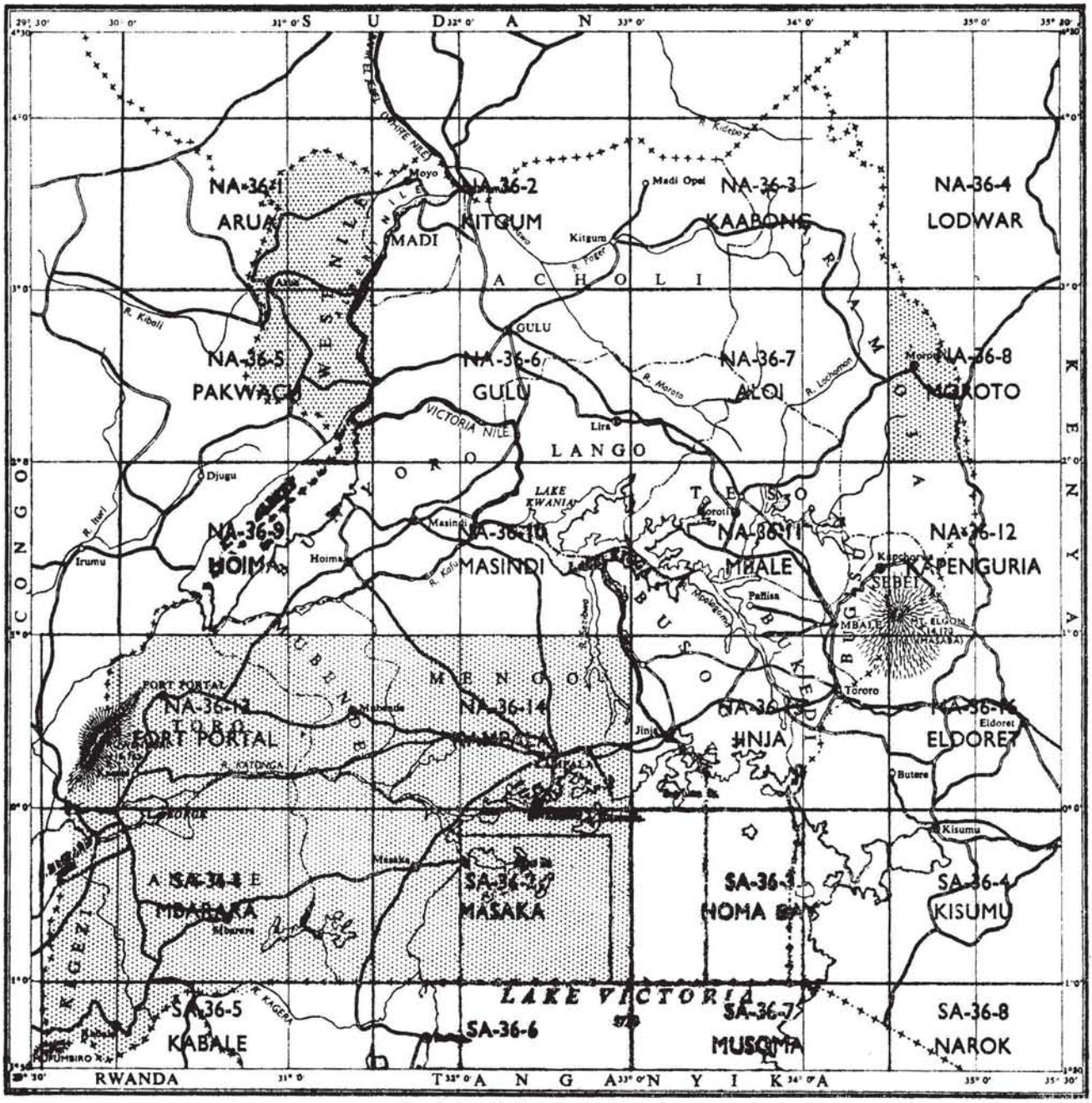
BUGANDA
JINJA
NA-36-16
ELDORET
SA-36-1
MBARARA
SA-36-2
MASAKA
SA-36-3
HOMA BAY
SA-36-4
KISUMU
SA-36-5
KABALE
SA-36-6
SA-36-7
MUSOMA
SA-36-8
NAROK
LAKE VICTORIA
WEST NILE
ACHOLI
LANGO
TESO
KIGEZI
RUWENZORI
ALBERT NILE
VICTORIA NILE
WHITE NILE
Moyo
Madi Opei
Kitgum
Arua
GULU
Lira
Moroto
Djugu
Irumu
Hoima
Masindi
Mbale
Tororo
Jinja
Eldoret
Kisumu
Mbarara
Kabale
FORT PORTAL
R. Kidepo
R. Pager
R. Moreto
R. Lochomor
R. Kibali
R. Ituri
R. Katonga
R. Kagera
LAKE KWANIA
LAKE KYOGA
Pallisa
Kapchorwa
MT ELGON
Mbale
Butere
Kericho
Nkokonjeru
Mpologoma
Mubende
Kasese
Rukungiri
Kabale
Mbarara
Masaka
Entebbe
Kampala
Jinja
Tororo
Eldoret
Kisumu
Lira
Gulu
Arua
Moyo
Kitgum
Moroto
Hoima
Masindi
Fort Portal
Mbale
Kapchorwa
Kericho
Butere
Musoma
Homa Bay
Narok

UGANDA 1:250,000 GEOLOGY
AT 30th APRIL 1963.

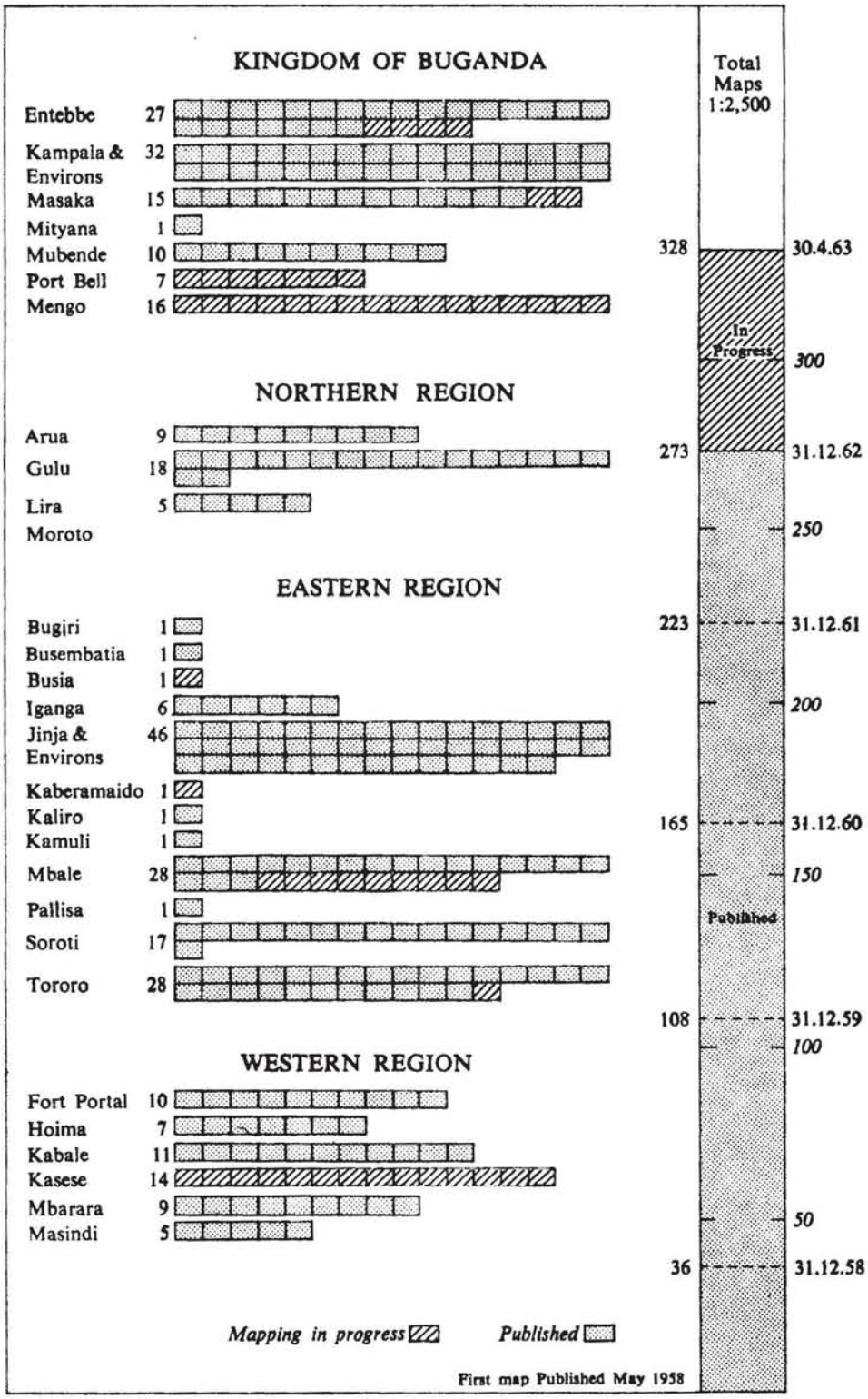


Compiled by the Department of Agriculture.
Drawn and printed by the Department of Lands and Surveys, Uganda.

IN WORK PUBLISHED

Uganda: index map geology 1:250,000

UGANDA 1:2,500 TOWN SERIES AT 30th APRIL 1963.



Compiled, drawn and printed by the Department of Lands and Surveys, Uganda, 1963.

Uganda: 1:250,000 town series

4. Atlas of Uganda

Published in 1962, the *National Atlas* includes 38 maps, the majority on 1:1,500,000 with texts, statistics and photographs opposite each map. It has sections on physical geography, climate, flora and fauna, human geography, rural economy, industry and trade, historical geography and town maps, with the mapping programme and a gazetteer.

5. Equipment

The photogrammetric section has one Wild A8 Autograph and one Nistri anaglyph machine.

The printing section has two single colour double demy Crabtree rotary offset presses, one Deffa quadcrown proofing press, and ancillary equipment. It has also a Wild VG.I enlarger and a microfilm unit.

6. The work of the following sections of the Department is only very remotely connected with cartography, and is only recorded briefly:

Lands section

All land in Uganda which is not registered in freehold is public land and is vested in 36 land authorities. The Department is land agent to all authorities in the administration of the public land estates.

Titles section

Responsible for the administration of the Registration of Titles Ordinance and Conveyancing.

Valuation section

Valuation for rating purposes of 50 towns, shortly to be increased to 95 by addition of smaller centres; for arbitrations, acquisitions and stamp duty.

REVIEW OF CARTOGRAPHIC ACTIVITIES IN EGYPT, U.A.R.[1]

1. Historical

Cartographic work in Egypt, U.A.R, is the responsibility of the following establishments:

(a) *The Survey of Egypt*

Established in 1898. Its first task was to complete a cadastral survey of the country for the re-assessment of land tax. Shortly afterwards the scope of the activities included the meteorological and hydrographic work "including the subsoil water table in the Delta", topographical mapping, levelling, geodetic work and crop surveys. Later on, the responsibility of meteorological and hydrographic work was transferred to independent services.

(b) *The present directorate of Military Survey*

Inaugurated in 1955 with aerial photogrammetry as the principal method of map making. The laboratories of Military Survey are also equipped with modern map reproduction machines.

(c) *The directorate of Hydrographic Survey*

Responsible of hydrographic operations, including work along the coast line of the Mediterranean and the Red Seas.

The following is a brief note on the main accomplishments in cartographic work on land.

2. Geodesy

(a) *Geodetic triangulation*

The first systematic triangulation began in 1899. The triangulation of the Delta was finished in 1901 and that of Upper Egypt in 1914. First order triangulation was, however, begun in 1907 to establish a framework in which the triangulations of lower orders would be fitted, and to establish data pertaining to the shape of the geoid in the region. By 1945 the geodetic triangulation had extended from Cairo to Aswan and from Cairo to the western and the Eastern frontiers near the Mediterranean coast. Geodetic triangulation was resumed in 1955 to establish first order triangulations in the desert regions which have become of tremendous economic importance. In the last seven years the lengths of the new first order chains added up to approximately 1,000 kilometres. The Wild T3 and T4 theodolites are used. Bases are measured by invar wires, and the use of electronic distance measuring apparatus is under study.

(b) *Levelling*

First order levelling began at about the same time as the geodetic triangulation, to provide a datum for irrigation projects. Due to the influence of the variation of refraction, however, the most of the first order levelling which had been undertaken before First World War was not up to the international standards set for this type of levelling. An improved procedure was developed and a new network of first order levelling was completed between the years 1927-1937.

Intensive researches have recently been carried out in connection with the statistical analysis of levelling errors. The results of these researches will be used for the planning of the programme of the third levelling of the Delta of the Nile and its fringes which will start in about 1965.

(c) *Gravity*

Pendulum stations were established at Helwan Observatory and fifteen other stations between 1908 and 1928. First order gravity work was resumed in 1960 in collaboration with the geodetic centres abroad (e.g. Uppsala University, Sweden).

Gravity differences were observed by the Worden gravity meter at about one hundred points. The first order

[1] The original text of this paper, submitted by the United Arab Republic, appeared as document E/CN.14/CART/72.

gravity stations of Egypt are well-connected with the international gravity bases.

3. Cadastral survey

The first cadastral survey was begun before the triangulation and proceeded village by village. As the triangulation progressed, each province was treated as an independent unit having its own sheet lines. As might be expected, the sheets on the boundary of one province would not fit the sheets of the neighbouring one. By 1914, the triangulation was complete and it became possible to have the cadastral survey of Egypt on a continuous triangulation. In the meanwhile the need was felt for a fundamental reform in the methods of land transfer and the records of right. A commission on the registration of title to land was set up in 1917 and by 1921 it made the following recommendations:

(*a*) The survey should revise the cadastral maps of the country since the old maps were out of date;

(b) The scale of the new cadastral maps should be 1:1,000 instead of 1:2,500;

(*c*) A land register should be introduced.

To carry out these recommendations the survey reference marks (heavy iron rails) were to be traversed and plotted for the village subdivision or parts thereof; and the property boundaries were to be demarcated with medium-sized rails and registered on the cadastral sheets. The topographical information was also to be added on the cadastral sheet to become a complete original at 1:1,000. It was also decided that all subsequent changes should be plotted original maps.

The progress of this second cadastre was slow. It had to be stopped during the war years, and the pressure of other work in the post-war period left little effort for cadastral surveying. Since nearly one half of the total area remained to be done and the older sheets had to be revised, a decision was taken to embark on a project of employing aerial photography in cadastral surveying. Analytical photogrammetry employing self-recording stereo-comparator (available at the Survey of Egypt) will be the basic operational technique.

4. Town mapping

Prior to 1933 the survey of towns was on the scale 1:200, and the results were published on a scale of 1:1,000. The maps of most of the principal towns and cities of Egypt appeared on this scale.

In 1933 the Cadastral Division of the Survey of Egypt took over the survey of towns from the topographical section of the department and henceforward the published scaletof survey in principal towns was 1:500.

An edition of Cairo on this scale was begun in 1935 and of Alexandria in 1938.

At the present time, the Air-Survey Division of the Survey of Egypt is engaged in two large projects on this field.

(*a*) The preparation of maps at the scale 1:1,000 for the planning of rural development;

(*b*) The preparation of maps at the scale 1:2,500 and 1:5,000 for town planning.

5. Topographical Survey

(a) *Topographical mapping in Egypt*

Topographical maps of Egypt were wanted, of course, as well as the cadastral, but it was not till the Survey of Egypt had been working for several years that attention could been given to this matter.

The normal series of topographical maps in Egypt are:

I. The 1:25,000 series for the cultivated regions. The second edition of this series was completed in 1956.

II. Maps at the 1:50,000 for some desert regions of particular economic interest.

III. The 1:100,000 series for the cultivated areas and about 50% of the desert regions.

It is planned to complete the topographical mapping of the country in ten years. This has become a feasible proposition by the introduction of aerial surveying.

Triangulation from aerial photographs is employed to reduce the amount of field operations needed to control the aerial surveying. At the Military Survey aerial triangulation is carried out on the first order plotting machines; and the adjustment is made numerically and, more recently, by the Jerie analogue computer. The Survey of Egypt adopts the analytical approach employing a self-recording stereocomparator.

(b) *Topographical expeditions outside Egypt*

In addition to the normal series, several topographical sheets at the scales 1:5,000 to 1:100,000 outside Egypt were made.

The following surveys were of particular interest.

I. In 1945 the project of an additional reservoir site in the Sudan was revived and the Survey of Egypt began an intensive mapping of the fourth cataract. From May 1946 to june 1947 the projective dam site was mapped on the scale of 1:5,000 with one metre contours. The Nile valley from Merowe to Abu Hamad (215 km) was also mapped at the scale 1:25,000 with 5 m contours. A line of first order levelling was done along the valley in this region and 49 cross sections were levelled.

II. More recently, another expedition from the Survey of Egypt undertook the survey of Ell-Madina and Mecca the holy cities of Islam, and a topographical survey of the road between them. The astronomical positions of both cities were determined, bases were measured and a chain of triangulation was observed between these two cities.

The two cities were mapped at the scale 1:10,000 and (in part) 1:5,000; and nine sheets at the scale 1:100,000, covering the motor roads between the cities, were made.

6. Crop Surveys

Since 1910 the Survey of Egypt has been reponsible for the determination of the areas under cotton and other crops. It was, in fact, in 1910 that the actual extent of the area under cotton throughout the whole of Egypt was evaluated for the first time.

At the present time there are three crop surveys every year, winter crops, summer crops and flood crops.

Experimental work on the use of aerial photography for crop surveying was successfully carried out at the Survey of Egypt in 1960 and 1961. The necessary equipment is being installed; and it is expected to embark on the full project before the end of the current year.

7. Cartography

(a) *Map projections*

The projection used is the Gauss Conformal Projection for mapping at the scale 1:100,000 and the larger scales. The Polyconic Projection is employed for the 1:500,000 sheets.

(*b*) *Scales and sheet boundaries*

Until 1922 the map series of the Survey of Egypt were constructed on the quadrant system (latitudes and longitudes). In 1922 this system was replaced by the rectangular system based on a kilometric grid.

The Survey of Egypt has so far published the following map sheets in the normal series:

I. 12,000 of the cadastral maps at the scale 1:2,500.

II. 500 topographical maps at the scale 1:25,000. The second edition ended 1959.

III. 67 topographical maps at the scale 1:100,000.

IV. 43 topographical maps at the scale 1:100,000 on a new system based on latitudes and longitudes.

V. 5,400 town sheets at the scale 1:500 and 1:1,000.

VI. 74 town sheets at the scale 1:5,000.

VII. 12 sheets at the scale 1:500,000 covering the whole of Egypt.

In 1959, however, a decision was adopted in favour of the return to geographical co-ordinates as the bases for map publications of the topographical sheets. The new system is based on the *International Map of the World on the Millionth Scale* as follows:

Scale: 1:1,000,000, $6° \times 4°$; 1:500,000, $3° \times 2°$; 1:250,000, $1° \times 1°$; 1:100,000, $30' \times 30'$; 1:50,000, $15' \times 15'$; 1:25,000, $7.5' \times 7.5'$.

The references were also changed according to the various needs of the maps.

The larger scale maps remain on the kilometric system.

(c) *The international maps*

I. *The "International Map of the World on the Millionth Scale"*

The publication of a map of Egypt to conform with the standards of the international million series was envisaged by the Survey of Egypt as early as 1912, but the First World War interrupted compilation.

After the war, a great deal of work was done towards the preparation of the "Cairo" and "Alexandria" sheets. The first edition published in 1923 was not contoured.

The sheets of Cairo, Alexandria, Aswan and a "provisional" Dakhla finally appeared in 1931 in accordance with the specifications of the international million maps.

Dakhla, Uweinat, Wadi Halfa and a small "make-up" sheet "Elba" were completed in 1934.

The seven 1:M sheets covering the whole area of Egypt and overlap also into the adjacent regions.

The preparation of the seventh sheet "Mecca" completed the series which has since become available in both English and Arabic.

II. *Aeronautical charts*

The publication of the aeronautical charts covering most of Egypt on the millionth scale to conform with the standards of the international aeronautical charts of the world, began in 1952. The four charts, Cairo (2447), Matruh (2448), Asyut (2544) and Farafra Oasis (2543) were published in 1954.

The languages used were Arabic and English to comply with the ICAO recommendations to use the native language with one of the three languages English, French and Spanish.

Two new editions were published in 1955-1957 with up-to-date information about the civilian aerodromes in Egypt. The fourth edition of these charts is now in hand with the latest topographical and aeronautical data.

Approach charts and landing charts for the civil aerodromes have been published in colours to meet the specifications of ICAO.

In accordance with the recommendations of ICAO the Survey of Egypt began to produce a new edition of the charts 2443—2542—2569 for Libya covering the eastern part of the kingdom. These will be the first Arabic and English editions of these charts.

III. *Transliteration*

The transliteration system which has so far been used in the international maps dates back to 1913. The system is however being revised in response to the resolution adopted by the Economic and Social Council on 27 April 1961 on the subjects of international co-operation in the standardization of geographical names. A decision was therefore taken to establish a Committee for the Standardization of Geographical Names. The Committee shall be composed of experts in geography, cartography as well as linguists. The Committee's responsibilities include:

(*a*) The preparation of lists of geographical names appearing on the international map series of Egypt;

(*b*) The recording of the pronounciation in current use locally;

(*c*) The study of the etymology and origin of each name;

(*d*) The re-consideration of the transliteration, particularly in connection with the way of representing the Arabic letters which have no corresponding latin letters.

(d) *Atlases*

The following atlases have been made by the Survey of Egypt.

I. The *Geographical Atlas of Egypt*, which has produced on the occasion of the Geographical Conference held in Manchester in 1928. The *Atlas* contains thirty-one topographical, geological, meteorological and economic maps in colours.

II. The *Meteorological Atlas*, which was made on the occasion of the Geographical Conference held in Paris 1941. The *Atlas* contains forty-one sheets showing the main meteorological data for the whole Nile Basin.

III. *Primary School Atlas* containing thirty-five geographical maps of the world.

In 1962, a decision was taken to make an atlas for advanced students containing eighty geographical and economical maps for U.A.R., the Arab Countries and the world.

(e) *Wall maps*

In addition to maps specially made for tourism, communications and statistics, the Survey of Egypt have published a series of wall maps including the following:

1.	The United Arab Republic	1:1,000,000 (physical), first edition
2.	The United Arab Republic	1:750,000 (physical), first edition
3.	The United Arab Republic	1:1,250,000 (administrative), first edition
4.	The United Arab Republic	1:750,000 (geological), first edition
5.	Governorates of Lower Egypt and Fayoum	1:200,000 (administrative), second edition
6.	Nile Basin	1:2,500,000 (physical), second edition
7.	Middle East	1:3,000,000 (physical), first edition
8.	The Arab World	1:5,000,000 (physical), first edition
9.	The Arab World and the Mediterranean Basin	1:8,000,000 (physical), first edition
10.	The Islamic State through the ages	1:4,500,000 (historical), first edition
11.	Syria	1:500,000 (physical), first edition
12.	Syria	1:500,000 (administrative), first edition
13.	Libya	1:1,000,000 (physical), first edition
14.	Africa	1:6,000,000 (physical), second edition
15.	Africa	1:6,000,000 (political), second edition
16.	Asia	1:6,000,000 (political), second edition
17.	Asia	1:6,000,000 (physical), second edition
18.	Europe	1:3,000,000 (physical), second edition
19.	Europe	1:3,000,000 (political), second edition
20.	North America	1:6,000,000 (political), first edition
21.	North America	1:6,000,000 (physical), first edition
22.	South America	1:6,000,000 (physical), first edition
23.	South America	1:6,000,000 (political), first edition
24.	Australia	1:5,000,000 (physical), first edition
25.	Eastern Hemisphere	1:5,000,000 (physical), first edition
26.	Western Hemisphere	1:5,000,000 (physical), first edition
27.	Map of the world (mercator projection)	1:20,000,000 (political), second edition

8. Publications

Since 1898 the Survey of Egypt has undertaken several researches in the various branches of cartography. The larger proportion of these researches have appeared as survey papers published by the Department in Scientific Journals. A complete list may be obtained on request.

REPORT ON CARTOGRAPHIC ACTIVITY IN AFRICA[1]

Part I. Historical introduction

Section A

Ground survey mapping

The preparation of proper topographical maps of the interior of Africa has been in progress for a much shorter period of time than the systematic charting of its coasts. During the nineteenth century British travellers were very active in putting the major features of the continent upon the map, but little geodetic or topographical survey work was undertaken in Africa South of the Sahara. However, at the turn of the century, it became apparent that better maps were essential for military, administrative and economic purposes. A first step was taken by the War Office, in 1900, with the publication of the first of a series of 1:1,000,000 scale sheets, planned to cover the whole continent on the sheetlines which had just been proposed for the *International Map of the World*. These maps were compiled from all available information and today they provide an excellent picture of the state of geographical knowledge of the continent at that time. At the same time survey departments were set up in most of the British dependencies in Africa (the year 1901, for example, saw the establishment of the organisations that were to develop into the present official surveys of Ghana, Nigeria and Uganda).

It was realized quite soon that surveys and mapping in Africa could not be tackled entirely on a local piecemeal basis. The grand conception of an arc of geodetic triangulation stretching the length of Africa from the Mediterranean to the Cape owed much to the vision and

[1] The original text of this paper, submitted by the United Kingdom, appeared as document E/CN.14/CART/47.

foresight of Sir David Gill, Her Majesty's Astronomer at the Cape from 1878-1907. The first section was observed in Cape Colony between 1883 and 1892. Subsequently work was taken up in the Rhodesias under the auspices of the British South Africa Company and by 1908 the Arc of the Thirtieth Meridian had been observed from the Cape to a point only 75 miles south of Lake Tanganyika. Further North, an isolated section of the Arc was observed in Uganda during 1908-1909 by surveyors who had been sent out to establish the position of the Uganda-Congo boundary. Unfortunately the work was then suspended for two decades because of lack of money The Northern Rhodesia and Uganda sections were finally. joined during 1931-1937, but the last gap, between Uganda and the Sudan, was not filled until after the Second World War. However, the vision of Gill and his associates has been fully justified as the Arc has provided means by which, within the last decade or so, the main triangulations of much of East and Central Africa have been welded into one system transcending national boundaries.

Another significant step was the formation of the Colonial Survey Committee in August 1905. This Committee acted as a watchdog over the newly established survey departments in British African dependencies. Its purpose was "to formulate a scheme which will ensure that all surveyors are trained in uniform methods, that uniform scales of survey are adopted, that the system of survey is adopted which is most suitable to the particular piece of country to be surveyed and that the work is carried on year by year with regularity and continuity". As a first step it was decided that all maps should be published at certain standard scales. For example, each department should attempt to map the whole of its territory at a scale of 1:250,000. In a number of cases military detachments were sent out from Britain to help with this task. In the course of nineteen months in 1909 and 1910 one such party of eight surveyors mapped 13,500 square miles of Uganda—a remarkable achievement, particularly when it is realised that over much of the area there was no pre-existing framework of triangulation. Another fine achievement was the singlehanded mapping of Basutoland by Captain M. C. Dobson, R.F.A. Recent air surveys have revealed the remarkable high standard of accuracy he achieved working in very difficult mountainous country. During the same period a good start was made elsewhere. notably in Kenya, the former Gold Coast and in Nigeria.

Unfortunately almost all work was halted by the outbreak of the First World War. When peace returned few Governments had much money to spare for triangulation or topographical survey. There were exceptions. Good progress was made between the world wars with the main triangulation framework in Nigeria and in the former Gold Coast and, in 1931, with the aid of a special grant from the United Kingdom Government, work was started on an ambitious plan for the primary triangulation of Tanganyika. Work on this was stopped by the Second World War, but, elsewhere in Africa, military requirements stimulated mapping and survey activities on an unprecedented scale. The war also served to emphasise the value of the newer techniques of air survey which permit large areas to be mapped by teams organised on a production line basis. When peace came it was clear that Africa was approaching a period in which ever increasing economic activity would call not only for more maps but also for larger scale and more accurate ones than those that had been hitherto available. It was against this background that, in 1946, the United Kingdom Government set up the organisation now known as the Directorate of Overseas (Geodetic and Topographical) Surveys.

Section B

Hydrographic Survey and Charting

British naval surveyors had done a certain amount of rather sketchy work around the coasts of Africa as far back as the eighteenth century but it was in the early years of the nineteenth century that a period of great activity commenced. Probably the most active of all the surveyors in these waters was Captain W. F. Owen who, in the 1820s, carried out surveys off both east and west coasts of Africa with a squadron of three vessels. The squadron consisted of H.M.S. *Leven* under Captain Owen, with H.M.S. *Barracouta* commanded by Commander Vidal, and a smaller tender for inshore work.

Owen's survey, which was largely a small scale coastal survey, with larger scale surveys of harbours, extended from Cape Guardafui southwards round the Cape of Good Hope to the Niger Delta, with some additional work off Sierra Leone and in the Gambia and Sherbro River.

After Captain Owen's surveys there was, for a time, little activity on the east coast; from 1828 and throughout the 1830s, surveying was concentrated on the west coast from Cape Spartel in Morocco, along the north west coast, and into the Gulf of Guinea as far as Fernando Po. The two greatest names of that period were Captain Belcher and Captain Vidal who in turn commanded H.M.S. *Etna*.

The east coast received attention again in the 1870s when Commander Wharton in the *Fawn* surveyed around Zanzibar and Pemba Is. and off the mainland coast. In 1884, H.M.S. *Sylvia* under Commander Aldrich and, from 1888-1892, the *Stork* under Commander Pullen were also working off the east coast. Commander Aldrich in the *Sylvia* surveyed off the south and south-west coasts, and, in 1886, the same ship under Commander Dawson was surveying in the River Gambia and Cape Juby areas on the west coast.

The rivers of West Africa and their approaches were examined and surveyed as trade opened up and some of the early surveys were carried out for fleet operations during times of disturbance. The last part of the nineteenth century and the early years of the twentieth century added considerably to our knowledge of the rivers Gambia, Sierra Leone, Sherbo, the great Niger delta and the Congo. Commander Purey-Cust and Commander Richards in H.M.S. *Rambler*, Commander Learmonth and Commander Walter in H.M.S. *Goldfinch*, Captain Monro and Captain Hardy in H.M.S. *Mutine* were responsible for much of this work. The *Rambler* and *Mutine* also continued southward with surveys of south-west Africa.

Many smaller vessels were at the same time occupied with survey work, especially in the river areas, fixing coastlines and obtaining soundings, so that by the early part of

the present century British surveys had laid the foundation for the charting of Africa: surveying and charting activity then passed to the French and Portuguese in the areas controlled by those countries.

Part II. Cartographic activities 1946-1963

Section A

General

The Directorate of Overseas Surveys was established to carry out geodetic survey and topographical mapping in the British dependencies overseas. Later arrangements were made through the Commonwealth Relations Office for its work to be continued in the independent countries of the Commonwealth under Mutual Technical Assistance Schemes, and, in 1961, the Directorate became part of the newly formed Department of Technical Co-operation in order to facilitate the growing volume of work done in independent countries. More than 1 million square miles have now been mapped by air survey methods, but much still remains to be accomplished. Current programmes of topographical survey and mapping in Africa are fully reported in Section B below.

The major part of Overseas Surveys' map production is basic medium scale mapping at 1:50,000. A standard 1:50,000 sheet usually covers a quarter-degree square (15′ latitude by 15′ longitude) and shows information vegetation and land use in addition to relief, drainage and man-made features. First editions usually consist of planimetric detail only, supplemented by hill shading where the topography requires graphic representation: revised and contoured second editions are normally published subsequently. Increasingly, and especially in East Africa, compilations are field checked by the country concerned to ensure that the published map shall be as accurate and up to date as possible. A summary of the British contribution to the basic mapping of Africa is given in appendix 2.

There has been a growing demand for land use, forestry, geological and soil mapping. Specialist investigation is undertaken by the Forestry and Land Use Section of the Directorate whose work is based on aerial photo interpretation supplemented by field studies in the territories concerned. Geological and soil maps are also prepared for printing from draft material supplied by geological survey departments and soil surveyors. Details of the maps produced appear under each country.

Hydrographic surveys have been carried out by H.M.S. *Owen* in 1958 and 1961 and details of these are given in section C below. As successive countries have attained their independence, however, they have set up their own survey organisations, so that in recent years British hydrographic surveying has been confined to a few large scale surveys of harbours and passage soundings and investigations of reported shoals. The rapid development of African territories has been reflected in increased charting activity both in the publication of new charts and in the issue of large corrections and new editions of existing charts. Details of these also are given in section C.

The Royal Air Force flew medium scale air photography of many countries in Africa between 1946 and 1952 and most of this has been used for basic mapping. Since 1952 commercial firms under contracts arranged by the Directorate of Overseas Surveys have flown over half million square miles of cover in Africa. Most of the photography is at scale of 1:30,000 or 1:40,000 and it was flown with a 6-inch camera. Large scale photography has also been taken for specific purposes, e.g. land use maps in the Gambia and township mapping in Sierra Leone; and in 1961 a Super Wide Angle camera ($3\frac{1}{4}$-inch focal length) was used to photograph part of the Bechuanaland Protectorate at 1:50,000. Some areas have not yet been photographed at all—notably those with particularly difficult weather conditions—and in others development and change have necessitated rephotography.

In 1956, the current cycle of R.A.F. small scale survey photography commenced, and cover at scales of 1:60,000-1:80,000, sometimes with simultaneous large scale fan cover, has been achieved in several countries. In 1962, photography of the Lake Victoria shoreline was requested by the governments of Kenya, Uganda and Tanganyika to record the unusually high level of the waters. Details of air photography are given in appendix 1. In addition, photography arranged by individual survey departments or by commercial firms has also been used for maps produced in the United Kingdom.

Direct assistance by the United Kingdom, whether in dependent or independent countries, is intended to supplement the work of the survey department of the country, so that essential maps, which are of vital importance for economic development, become available sooner. There is no question of the United Kingdom being entirely responsible for the basic surveys of these territories, and the more work which can be done by the country itself from its own resources, the better.

Consequently a further important and increasing British contribution to the surveying and mapping of Africa is the provision of training in new techniques and equipment for officers nominated by overseas Governments. In the past four years eighty-six members of Commonwealth and Overseas Survey Departments have been attached to the headquarters of the Directorate of Overseas Surveys for individual training in such subjects as air survey mapping, cartographic methods, computing, reproduction, and the organisation of a large map production unit. Officers have come from Egypt, Gambia, Kenya, Libya, Nigeria, Northern Rhodesia, Nyasaland, Sierra Leone, Sudan, Tanganyika and Uganda and all have had previous experience in their home departments. A number of surveyors have also been attached to the Directorate's field parties overseas for training.

Section B

Progress of ground surveying and mapping by countries

Basutoland

Survey and mapping in Basutoland commenced in 1950 when maps were needed for the Orange River hydroelectric scheme and for soil conservation purposes. The whole country was photographed by the Royal Air Force in 1950 and again in 1952. A survey party commenced reconnaissance and beaconing of primary and secondary

triangulation in 1950 but was hampered by drought and the consequent lack of grazing for the pack animals. Field work finished in 1954 when triangulation was completed and height control had been obtained for the lowland and foothill areas of the territory and along the Orange and Senqunyane Rivers.

Maps were urgently required by the Orange River hydroelectric scheme and, by 1952, 11 uncontoured preliminary plots at 1:50,000 had been issued. The engineers required contours up to 5,500 feet above sea level and, in 1954, contoured overlays were produced for parts of 10 sheets.

By 1956 the whole country had been covered by 60 planimetric sheets and, where there was sufficient height control, work had been proceeding on the contoured edition. The first contoured sheet was issued in 1954 and included an agricultural pilot scheme in the north-west. Further height control was needed in the mountainous areas and two surveyors returned to observe this. In spite of high winds, low temperatures, torrential rain and rugged relief the surveyors completed their work between 1956 and 1958 and by March 1963, 42 of the 60 1:50,000 sheets had been issued and 5 more were well advanced.

During 1961 and 1962 the whole Protectorate was rephotographed to provide up to date cover for the geological investigation of mineral resources and water development projects.

At the request of the Department of Agriculture sheets at 1:15,000 are being prepared for a number of catchment areas and the first of these for the Mejamatalana Catchment has been printed.

Bechuanaland

Photography was commenced in 1948 by the Royal Air Force in the south-east of the country along the line of the border with South Africa and the railway from Bulawayo in Southern Rhodesia to Mafeking in South Africa. By the end of 1950 about a fifth of the Protectorate had been covered including all the more populated country in the south-east. In 1951 the Okavango swamp area in the north was photographed under contract.

Mapping was first needed in the Okavango Swamp area and late in 1952 a survey party commenced control by astro-radio fixes. Unusually heavy rains made movement very difficult and observations were hampered by cloud but the control was completed during 1953. Considerable difficulties were met in the interpretation of the photographs as some of the rivers were said to run one way in the dry season and the opposite way in the rainy season. The first two sheets at 1:125,000 were published in 1955 and the whole area, covered by 17 incountoured sheets, was finished in 1956.

Mapping of the south-east area was needed in connection with schemes for improved water supply, agricultural development and the geological investigation of mineral resources. The first ground control in this area had been commenced in 1949 by continuing the South African triangulation into the Kayne-Lobatsi area. Work re-commenced in 1953 and, by means of secondary triangulation, Mahalapye was linked northwards to the Southern Rhodesian border by July 1957. A very flat and featureless area then remained between Mahalapye and the Kanya-Lobatsi area and, during 1958, control was provided here by astro-fixes. This method was also used in the flat area west of Francistown in 1958 to provide control for mapping the Makarikari area. The 37 uncontoured sheets at 1:125,000 covering the south-east were completed by 1960. A block of 39 sheets extending across the Protectorate from Makarikari to Ghanzi was begun in 1958 and with their publication in 1961 over a third of the territory had been mapped at 1:125,000 scale.

In 1961 a contract was let for photography of the West Bangwaketse and Bakwena Reserve in the southern part of the territory and for western Ngamiland. This produced about 40,000 square miles of photography using a Wild RC9 Super Wide Angle camera. A further contract in 1962 completed the photography of the north so that now about two-thirds of the territory, i.e. most of the area outside the Kalahari Desert, has been photographed. An anbitious programme has been drawn up to provide over a ten-year period a rigid control framework covering the whole Protectorate. This will be done by observing a network of tellurometer traverses. A D.O.S. field party has now started work on this project and one of their first tasks will be the provision of control for 1:125,000 mapping of the West Bangwaketse-Bankwene area.

All the maps produced so far have been uncontoured but the Directorate has now been asked to prepare contoured 1:50,000 maps of large areas in order to assist the proper development of the country's water resources. Large scale mapping of certain townships at 1:2,500 or 1:5,000 is also planned. Work on Lobatsi will commence later in the year followed by Serowe and Tonato Village

The Gambia

During 1946-1947 the Royal Air Force obtained photography of the whole of the country at 1:30,000 and of the Kombo peninsula at 1:10,000. Thirty sheets at 1:50,000 were compiled from these photographs and all were published in 1948.

In January, 1954 work started on the measurement of the first of a series of precise traverses to form a framework for the control of cadastral surveys. The first loop crossing the river south of Farafenni at Longitude 15° 35′ W was closed in 1955. The second loop crossing the river at Kuntaur at longitude 14° 53′W was finished in 1957. The Directorate's surveyors were then withdrawn and the remainder of the traverse was observed by surveyors of the Gambia Survey Department.

In 1956 a 3-sheet map at 1:125,000, reduced from the 1:50,000 series, was published. In the same year central Gambia was rephotographed to enable a land use survey to be made. The result of this was a fully-coloured Land Use map at 1:25,000 using detailed information prepared by the Land Use officer: this was completed in 1960 with the publication of 34 sheets.

During 1960 a small amount of large scale air photography was obtained for engineering works connected with the coastal defence of the Bathurst area. In order to emphasise water limits, infra red film was used and photography was taken at both low and high tide. This photography is now being used for 1:2,500 mapping of the Bathurst and the Fajara-Cape St. Mary area.

Revision of the 1:50,000 series is also proceeding as revision material is received and the first two revised sheets are being printed.

Ghana

The first mapping project was to provide small scale surveys in connection with the proposed hydroelectric scheme on the Volta River.

To meet the immediate first requirement of large scale maps the Royal Air Force photographed the Volta River at 1:30,000 and the delta and area around Ajena at 1:5,000 and 1:10,000 in 1946-1947. A survey party commenced work on providing ground control for the photography in 1946 and this was completed by the end of 1947. Eight sheets at 1:5,000 of the delta area were issued first followed by 22 covering the Ajena and Volta River area in 1948. In 1949 copies of all relevant sheets, for the river area south of Kete Krachi, with selected contours marked on them were supplied to the consulting engineers for the Volta River Scheme, and, in 1951, 11 contoured and 9 uncontoured were issued at 1:50,000.

The next priority for mapping was the probable flood area of the river and its tributaries north of latitude 7° N. Between 1948 and 1952 photography had been flown by the Royal Air Force and under contract of all but the south western third of the country. In 1951 field surveys were commenced but work was delayed by prolonged and heavy rains which caused flooding. Mapping followed closely on the supply of survey data and 57 sheets, of which 36 were fully contoured and 11 part contoured, were issued by 1954.

No further work was undertaken by the Directorate until, in 1959, arrangements were made with the Ghana Government for a long-term plan under which the Directorate was to co-operate with the Ghana Survey Department in mapping 54,000 square miles of Northern Ghana under the United Kingdom/Ghana Mutual Technical Co-operation Scheme. Mapping at 1:50,000 with 50-foot contours was required in connection with the development of agriculture, health services and communications under the Ghana Government's Second Development Plan. The Directorate undertook to plot contours for nearly 200 sheets and to second one surveyor to the Ghana Survey Department to train Ghanaian surveyors in the identification of ground control points on air photos and the establishment of height control by altimeter. Work commenced in the Yendi area and, by March 1963, height control had been put in for the Fra Fra-Kusasi, Nasia River, Navrongo, Wiasi and Tamale blocks. The contouring programme was initiated in 1960 and by March 1963 work was progressing on the production of the 6 sheets of the Yendi, 13 of the Fra Fra-Kusasi and 7 of the Nasia River Blocks. Future mapping covers the remainder of Ghana north of 9° N and east of 0° 15′ west and the Navrongo, Wiasi, Tamale and Bui blocks.

Kenya

Before the end of the Second World War about a third of the country had been covered by topographical mapping but because much of this was out of date it was necessary to start the mapping of the country afresh in 1946.

Air photography was commenced by the Royal Air Force in 1946-1947 and, by 1950, about a third of the country, comprising most of the highland area in the south-west and two coastal areas, had been flown. In recent years the R.A.F. have undertaken the photography of the Northern Frontier area at 1:80,000 and have rephotographed the whole of the Highlands at 1:50,000. The remaining areas, including the coastal belt were mainly photographed under contract and by 1963 all but a few isolated gaps had been covered.

The first maps of Kenya produced by the Directorate, were 66 planimetric sheets of a 25-mile strip along the Kenya-Ethiopia border, followed by contoured sheets of the Voi area in the south-east for a water-supply project.

In 1951 work commenced on providing a primary triangulation network. The first base was measured at Kisumu, on the eastern edge of Lake Victoria and a link was made between the Kenya and Uganda systems. Work proceeded south-east on a primary chain running along the Kenya-Tanganyika border to the coast near Mombasa. In 1953 a link was made with the Tanganyika triangulation east of Mt. Kilimanjaro and a second base measured at Malindi in 1954. This primary chain was not completed until 1957 because of the interruption of the work during the "Emergency". In that year a third base of just over 13 miles was measured north of Isiolo and observations of the primary chain northward from the border to this point were completed. This was followed by chains linking Isiolo and Kitale and Nairobi and Eldoret, both completed by the end of 1959, but the most notable achievement during this period was the observation of a tellurometer traverse 400 miles long between the Malindi and Isiolo bases—this was completed in 28 days during August 1957.

The Directorate's surveyors have observed several extensive secondary networks of triangulation or tellurometer traverses. In 1959 and 1960, for example, one such network was established by tellurometer traversing in the Maralal-Lake Baringo area in the rift valley, and similar work was also undertaken in the Taveta-Taita area. In both areas the control was needed for 1:50,000 mapping.

In 1952 there was an urgent request from the Kenya Government for a block of 20 sheets north-east of Nairobi covering the Kikuyu reserves and including Mount Kenya, and, with the help of the Directorate of Military Survey, who assisted in the supply of additional control, this was finished in 1953-1954. These and the following years saw the completion of 1:50,000 planimetric mapping of the "Highlands" and a number of areas, e.g. around Mount Kenya, were contoured.

Completion of work in the central areas permitted greater priority to be given to the Mombasa area where mapping was required in connection with land consolidation, soil conservation and water control. The 36 sheets covering this block were finished in 1959.

Three important tasks either recently completed or still in progress have been the mapping of the Maralal and Taita areas, and the contouring of a large block of existing sheets in South Nyanza. The latter was mapped only eight or nine years ago, but so many changes have taken place since then that the sheets had to be completely recompiled

from up to date air photographs. Perhaps the most important recent task has been the preparation, in conjunction with the Survey of Kenya, of 1:100,000 mapping with 25-foot contours of potentially irrigable areas along the middle Tana River.

In 1960 several specialist mapping projects, required in connection with the agricultural development of the country were begun. Four sheets at 1:250,000 are in hand for the land utilisation survey of the Kenya Highlands and preparation was undertaken of a series of soil maps at 1:50,000, surveyed by the local Agricultural Department in connection with an African Land Development Programme. By 1963, 13 soil maps had been issued; these covered the Songhor area, the site of a proposed sugar plantation, and the East Konyango area in Nyanza Province, and the Nairobi-Machakos area. In 1957 a hill-shaded map of Mount Kenya at 1:25,000 was produced.

In preparation for the granting of full independence to Kenya, a need arose for large scale mapping (1:2,500) for use in allocating land holdings. The amount of work involved, particularly in plotting from air photography, was beyond the capacity of the Survey of Kenya to complete in time. At their request therefore a party of 12 military surveyors from the United Kingdom went to Kenya in December 1962 to put in ground control for air photography, using tellurometers. The task of supplying control was completed by March 1963, and the plotting will be completed by the end of 1963.

The ground survey party, again at the request of Kenya, also carried out the demarcation and co-ordination of part of the boundary from Katumba to the Galana River before returning to the United Kingdom in May 1963.

As part of a series to provide cover at 1:250,000 of Kenya, Tanganyika and Uganda the War Office has undertaken production of 23 sheets of Kenya. In this programme 9 sheets have been issued and a further 12 are well advanced. Extension of this programme to complete cover of the whole of Kenya is under consideration.

Northern Rhodesia

Two large projects, the Central African Rail Link and the Kariba scheme on the Zambesi dominated mapping in Northern Rhodesia until 1953. By then the Royal Air Force had photographed all but the western quarter of the country. Control surveys for mapping were started in 1948 in the Kariba section of the Zambesi valley, and by 1951, 72 sheets had been issued, of which 6 were contoured.

The Central African Rail Link was projected to run from Kapiri Mposhi in Northern Rhodesia to Taveta in Tanganyika. During 1950-1951 most D.O.S. surveyors in Central and East Africa were concentrated on providing control along the proposed route.

The next major area to be mapped was the Copper Belt, Western Concession area. Despite the difficult nature of the country which restricted the use of triangulation and made extensive theodolite traversing necessary, control was completed in 1952 and, by 1964, 39 sheets had been issued, of which 12 were subsequently contoured.

At this time the possibility of erecting dams in the Kafue Gorge and in the Meshi Teshi Gap was under consideration and extensive mapping was undertaken to determine the area which would be flooded by the proposed works.

In 1946 the only first order triangulation of the country was the arc of the Thirtieth Meridian. In 1964 it was decided to run a short chain of primary triangulation to connect this to the secondary work in the vicinity of Lusaka. Since then the primary framework has been considerably extended. The most important achievements have been, linking the Arc with the Nyasaland triangulation, near Lilongwe, observing a network from Livingstone to Lusaka, tied across the Zambesi to many Southern Rhodesia stations, and observing the great Kasempa loop which swings away from the Copper Belt around the Kafue headwaters to join with the triangulation west of Lusaka. This chain, which was fully observed by the end of 1960, provides the frame for the secondary control for mapping of the Kafue Basin north of 15° S. Control and mapping of this area, of over 80 1:50,000 sheets was undertaken as a top priority task in 1961, in connection with the United Nations Special Fund investigation of the resources of the Basin. The topography is relatively featureless and, in order to meet the urgent demands for mapping control under these conditions, many of the control points were placed by bearing and distance, measured by tellurometer, from existing primary and secondary stations.

Advance film positives of the compilations were supplied so that single colour copies of the map could be printed at an early stage and made available to field workers. During the first part of 1963, 81 sheets of the Kafue Basin were produced and a number of sheets are still in hand. Field work is now in progress for the mapping of the Mwinilunga area in the north-west which will be taken up when work in the Kafue Basin is complete. In the meantime, contouring is proceeding on the Kafue Headwaters area where this is required to assist in water conversation

Nyasaland

Prior to 1946 no geodetic triangulation existed in Nyasaland. A beginning was made in January 1948 with the measurement of a base of just over 14 miles near Blantyre and the primary chain of triangulation linking this to the Arc of the Thirtieth Meridian near Mbeya in Tanganyika was finished in November 1953.

By 1951 the country had been photographed by the Royal Air Force except for a few small gaps which were later filled in. First priority mapping was for the southern part of the Protectorate, and, by 1952, 54 sheets at 1:50,000 had been published. Unfortunately the pressure for these maps was such that they had to be compiled in advance of the completion of the primary triangulation.

In 1956 work began on a breakdown of the primary triangulation to secondary and the supplying of height control north of 14° 30′ south. Concentration was on the Lilongwe-Dedza area and on an extension along the shore of Lake Nyasa to Kota Kota. Contoured maps of the Lilongwe-Dedza area were prepared and all sheets published by 1962.

It was then decided that the 1:50,000 mapping should be steadily extended northward from this area to the Tanganyika border. With this aim in view all parts of the area which had not been recently covered were rephotographed under contract in 1962.

By the end of that year secondary control, established by tellurometer traversing between existing primary stations, and height control was complete north of 13° south. The first sheets of the Mzimba area have now been compiled and sent to Nyasaland for field checking.

Mauritius

In 1949 the Institut géographique national agreed to photograph the island in conjunction with their own work in Réunion. Using the triangulation framework established by the Royal Engineers in 1934, 13 1:25,000 sheets were compiled covering the whole island, and contoured editions of these were published between 1955 and 1959.

In 1962 a surveyor visited the island to provide a denser network of ground control points. At the same time tellurometer measurements were made of check sides in the existing triangulation. A soil map of the island at 1:100,000, prepared from material provided by the Sugar Research Institute, was produced in 1962.

Nigeria

In 1948 the Nigerian Government invited the Directorate to undertake mapping from air photographs for which the Nigerian Survey Department would carry out the necessary ground control surveys. Air photography commenced in November 1948 by the Royal Air Force and by the end of 1951 about half the Northern Region had been photographed, but attempts to cover areas further south were largely abortive.

Fifty-one sheets were issued as preliminary plots at 1:62,500 in 1950 for an area west of Kaduna using data supplied by the Survey Department, and in 1951 work was started on 30 sheets in the Shendam and Zamfara River areas. At this point mapping scale was changed to 1:100,000; 6 sheets were published in 1953, and then 10 sheets were completed of a densely populated area north of Kano.

In 1954-1955 a block of 24 sheets of the tin mining areas of the Jos plateau was published at 1:50,000. Some of these sheets have since been contoured.

The Directorate was then asked to change the normal scale of publication to 1:50,000, and mapping at that scale has since been extended steadily eastward from Kano to the shore of Lake Chad.

Air photography recommenced in 1954, under contract, of areas in north Nigeria and the (former) Cameroons. Photographed of the latter area and of adjacent areas of Eastern Nigeria has made slow progress owing to very unfavourable weather conditions.

The first D.O.S. field party in Nigeria and the Cameroons began work in 1956, in the former Southern Cameroons extending the existing Nigerian primary triangulation framework and later breaking it down into secondary and minor control for mapping from air photography. Conditions were difficult because of the physical character of the Cameroons, heavy rains and cloud in the wet season and the Harmattan dust in the dry. At Independence in October 1961 secondary control was in progress in the southern part of the country and five 1:50,000 sheets had been published. The field party was then moved to Eastern Nigeria.

In Northern Nigeria another field party was established in 1959 to provide height control in areas north and east of Jos. The party next moved to the Mambilla plateau in south-east Benue Province where the main task was the establishment of ground control for 1:50,000 mapping by running tellurometer traverses between existing primary triangulation stations. This was interrupted in 1961 by an urgent request from the Ministry of Lands and Surveys for control for 1:25,000 mapping in the Lokoja area for the proposed development planning of iron deposits in the nearby Jakura limestone plateau. Control for the Jalingo Mambilla block was completed by March 1963.

Since 1961 the party in Eastern Nigeria has been engaged in controlling the Bende, Cross River and Calabar areas, but work has also begun for the large scale mapping of Port Harcourt and environs. A special task undertaken in East Nigeria in 1962 was the photography and mapping of a number of farm settlements to which the Regional Government attach the greatest importance.

In the Western Region work is in progress on the production of 33 sheets at 1:1,200 covering the outskirts of Lagos. This work has been made difficult by the rapid changes which are taking place there.

Seychelles

Large scale photography was obtained for most of the islands in 1960 including coastal waters and outlying reefs. Compilation has been completed of eleven 1:10,000 sheets covering the island of Mahé; these will shortly be published.

Sierra Leone

Between 1946 and 1951 almost all the country was photographed at 1:30,000 scale by the Royal Air Force. Much of the cover was, however, affected by haze and between 1956 and 1961 the whole country (except for a gap in the far south) was rephotographed under contract.

The first mapping to be taken up was a 1:10,000 block of the Freetown area, covering approximately 500 square miles. The first sheets were published in 1951. In 1955 mapping of the peninsula with new photography was resumed. Seven revised sheets were published in 1960 and by 1963 work was in hand on the remaining 15.

The establishment of a primary triangulation and tellurometer traverse network for the western half of the territory was commenced in 1958 but progress was very slow because of exceptionally difficult weather conditions. Constant low cloud made angular observations almost impossible so it was decided to run a primary tellurometer traverse round the perimeter and establish control within the area by trilateration. The north west was completed in 1960 and the party moved to the south-west area where a perimeter traverse was run along the coastal belt from Cape St. Ann to Sulima. The work was finished in 1963 and extended into the south-east block.

In 1958-1959 provisional planimetric sheets were urgently required for some Agricultural Development areas in connection with a rice-growing scheme; subsequently these were published with land-use overprints.

In 1959 preliminary work was started for 1:50,000 mapping of a block of sheets in the north-west and by 1963,

37 had been published. Relief was shown on most sheets by hill shading, but contouring has now been started. A further block in the south-west is well advanced.

During 1960 and 1961 large scale photographic cover was obtained of the towns of Bo, Makeni, Kenema, Pujehun, Moyamba and Kailahun in preparation for the future production of township maps at 1:2,500. The 1:2,500 contoured map of Bo in 15 sheets is already in production.

Somali Republic

(Mapping was undertaken in the former British Somaliland)

The first photography was flown by the Royal Air Force in 1946-1947, and, by 1953, the whole of the Protectorate had been photographed.

Control was supplied mainly by astrofixes and the mapping of the country commenced in 1951. The first four sheets were published at 1:50,000 but it proved practicable to show the same amount of detail at 1:125,000 and, by 1957, the whole country had been covered by 68 incontoured sheets at the latter scale.

In 1956 a survey programme was commenced to supply planimetric and height control over various small areas, of which maps were required for special purposes. This involved surveys (i) to check the existing township plans of Hargeisa and Berbera (ii) of the catchment area to the west of Hargeisa in connection with the Hargeisa water supply and (iii) of the Gwan Libah and Al Madu forest areas in connection with re-afforestation schemes. Mapping of the latter was still unfinished when work was suspended in 1960.

Several coloured geological sheets at 1:100,000 have also been published.

A programme of 9 sheets at 1:500,000 covering most of the Somali Republic is in the early stages of compilation by the War Office.

Swaziland

The whole territory was photographed by the Royal Air Force in 1947-1948 and control for mapping based on the South African triangulation was put in in 1948 and 1949. Mapping was commenced in 1950 and by 1955 31 uncontoured sheets covering the whole country had been published. The contouring of the last of these was completed in 1962. The Directorate agreed in 1954 to undertake a primary and secondary triangulation of the Protectorate to connect it to the South African triangulation. This was to provide a framework to control the growing volume of cadastral surveys. The Protectorate was rephotographed in 1961 under contract to assist land-use planning and agricultural re-settlement programmes; the photographs will also be used to revise the 1:50,000 maps. Three soil maps covering part of the Lower Usutu Basin at 1:50,000 were issued in 1961 and by 1963 20 geological maps at 1:50,000 had also been published.

Tanganyika

The production of maps of Tanganyika has been very linked to a number of specific projects, including the ground-nuts scheme, the Central African Rail Link and the Red Locust Control and to many projects concerned with this water control.

The first East African mapping to be undertaken by the Directorate was of two areas, Urambo and Masasi, in connection with the Overseas Food Corporation scheme for the mechanized cultivation of ground-nuts. The area was flown by the Royal Air Force and by 1948 30 provisional plots had been issued at 1:50,000.

Photography was obtained of the Western Province area in 1947-1948 and the first field survey work put in control for the area south and west of Tabora; 49 uncontoured sheets were subsequently produced.

In 1949 work was concentrated on mapping for the Central African Rail Link. In the fairly open hilly country east and south-west of Mbeya work progressed quickly and height control was provided by 1951.

In 1951 an urgent request was received, to facilitate the work of the International Red Locust Control Service, for the mapping of 10 sheets covering the country immediately to the west of Lake Rukwa where locusts were breeding. Air photography existed but very little ground control, so it was decided to assemble slotted templates for an area covering 50 sheets to link up with all possible control and, by 1954, 30 uncontoured sheets had been produced. In 1957, a further 14 sheets at 1:50,000 were compiled for the use by the International Red Locust Control Service, in the Malagarasi area.

Before 1946 Tanganyika possessed a more extensive primary framework than any of its neighbours. In June 1953 work was begun on a chain of about 600 miles in length in the south east, breaking off from existing triangulation near Morogoro, running south along the coast to turn west along the Mozambique border, and connect with Portuguese triangulation; it finally turned north along the east of Lake Nyasa, connected across the lake to the Nyasaland triangulation, and returned to the existing Tanganyika triangulation near Mbeya. A base line of approximately 11 miles was measured at Nachingwea in 1954.

Secondary triangulation and planimetric control for mapping of an area round Dar es Salaam and a somewhat larger area near Iringa were commenced in 1953, but, in 1954, there arose an urgent need for contoured maps for irrigation purposes in the basin of the Ruvu River, the Usambara Mountains and surrounding country, and the Kilombero Valley. Field surveys in the Ruvu River Basin and Usambara were completed by 1956, and by 1958, 55 contoured sheets had been produced.

The Kilombero water control schemes were given priority after the coastal areas. Considerable difficulty was experienced in obtaining complete photography and some small gaps remained when the maps were published. Most of the sheets were issued by 1959, about half being contoured.

During the dry seasons of 1958 and 1959 secondary and minor control was established in the Usangu Flats area where mapping was urgently required in connection with the Food and Agricultural Organisation Rufiji Basin investigation. Contoured maps of this area were published in 1960.

Further water development requirements led to the resumption of survey work in the Dodoma-Morogoro block in 1958 and subsequently to concentration of effort on to the Bubu River area to the north of Dodoma. By 1962, control had been established for this very large area and work could be taken up in the unmapped section of the Pangani Basin, including an area extending north to Kilimanjaro and west to the rift valley lakes Manyara and Natron. Much of this area was photographed in 1962 and it is planned that the remainder, together with South Masailand, will be covered in 1963. By March 1963, work was in hand on nearly 100 sheets in the Bubu and Pangani blocks. Most of these sheets are to be contoured.

Uganda

Uganda had a considerable amount of triangulation in 1946 but apart from the Arc of the Thirtieth Meridian, it was not up to primary standard. However, since work started in Karamoja in 1948 new first order chains have been observed which effectively "box" the whole country, and great progress has been made in filling in the areas between these chains with networks of secondary stations. The primary work was completed with a programme of astronomical work in 1958.

Progress of mapping in Uganda at 1:50,000 has been less obviously linked to major development projects than in the other Central and East African countries, and, in the main, it has been possible to work fairly steadily across the country, which will soon have been completely covered by 1:50,000 map sheets.

The first area to be mapped was the Karamoja district, where no triangulation existed. The district was photographed by the Royal Air Force in 1947-1948 and control was completed by the end of 1950, a secondary and minor control being observed simultaneously. This was followed by a block of mapping in the west of Buganda.

By 1956 most of the country had been photographed. Several attempts had to be made however to obtain photography of the south-west, including the Ruwenzori mountains, where the weather was generally very adverse.

Survey work commenced in south west Uganda in 1954. The greater part of the area was ideal country for triangulation, hilly and open, and work progressed quickly, to be completed in 1955. The party then moved east supplying planimetric control in Mengo and the East Ankole-Masaka areas. During 1960 contoured editions, many incorporating local revision material supplied by the Lands and Surveys Department were completed for all these areas.

In 1956 work was started on 7,500 square miles in north-west Uganda and the secondary triangulation and minor control were completed in 1958. First priority was given to sheets along the Albert Nile, where water control schemes were being considered.

There had been pressure for some time for up-to-date maps of an intensively farmed region stretching from the Kenya frontier across the Eastern Province to Lake Kyoga. A very successful photographic contract produced 21,000 square miles of photography during the 1959-1960 flying season. Survey was by secondary tellurometer traversing and, commencing in the Mt. Elgon area in 1958, the surveyors worked west via Lake Kyoga to the Bunyoro and Katonga areas: they then moved north into the Gulu and Acholi areas.

A map of Central Ruwenzori was compiled in 1959 and photographic copies despatched to the territory for the addition of detailed information relating to mountaineering. Extensive experiments were carried out in the use of hill shading and relief colouring to supplement the contours on the sheet and the final 1:25,000 map was issued in 1962.

By March 1963, 9 sheets in the Mt. Elgon area were printed contoured and 4 in the Eastern Province, while 24 were in production together with 26 Kyoga, 16 Mubende and 18 Bunyoro sheets. Future mapping will include 38 sheets of the Gulu area and the preparation of revised contoured maps of Karamoja. When this is finished Uganda will be the first country in eastern Africa to be fully covered by contoured 1:50,000 maps.

Zanzibar

Two sheets at a scale of 1:63,360 covering the island were first published in 1947. These were compiled from a set of fifty 6″ to 1 mile sheets dated 1930 and revision material supplied from Zanzibar. A revised edition was issued in 1952.

During 1961 a type classification of the Mangrove areas was carried out from air photographs and the results supplied to the Forest Officer for checking before the final maps are produced.

Miscellaneous

Colonial Office list maps have been produced for all countries and repeatedly revised. A map index for each country is included in the Directorate map catalogue. The majority of other miscellaneous maps have been in connection with reports. The following are just a few examples of these:

Three sheets at 1:5,000,000 showing the incidence of the tsetse fly in Africa south of the Sahara were issued in 1953. Twelve special maps were produced to illustrate the report of the Central African Rail Link Development Survey 1952, four for "The Report of a Mission to the Bechuanaland Protectorate to investigate the possibilities of economic development in the Western Kalahari, 1952" and four to illustrate the Royal Commission on East Africa in 1954.

Other reports have required small scale maps of the Okavango Swamps and surrounding areas in Bechuanaland, sketch maps of an area in Northern Rhodesia for use in photo-forestry work, five maps illustrating the general geography and development of water resources for Basutoland, Bechuanaland and Swaziland and seven for the Handbook of the Natural Resources of East Africa.

SECTION C

PROGRESS OF HYDROGRAPHIC SURVEYING AND CHARTING

H.M.S. *Owen* carried out a survey of the Approaches to Mkoani, Pemba Island, in 1958 and surveys of Lamu Harbour and the Approaches to Lamu, Manda and Patta Bays in 1961.

H.M.S. *Owen* arrived at Pemba on 19 January 1958 and anchored midway between Mesale Island and Mkoani. Tide camps were established at both places and reconnais-

sance parties were despatched to East Island, Ras Kingoje, Kwate Island and Mkoani. When the tidal and theodolite observations had been completed the ship moved in closer to Mkoani but, as boat reconnaissance had revealed some dangerous unguarded pinnacles in the Approach Channel, it was not thought prudent to take the ship up to the inshore berth. A detached party was established at Mkoani with two survey motor boats, a dory and a dinghy and left there for three months carry out the survey, while H.M.S. *Owen* left for Mombasa and the Seychelles. It was the intention for the ship to return to Pemba in March to supervise the Mkoani survey and complete the outer area but this turned out to be impossible as the *Owen* was required by the C.-in-C. East Indies for operational duties. The survey was completed as far as the detached party could take it and the differences from the published chart were found to be numerous. Many shoal patches were found and those on or near the fairway into Mkoani were examined or wire swept and others were closely interlined.

This survey has been used to correct the existing charts for essential information but the new charts which the Zanzibar authorities requested have not yet been commenced as it is not yet known where port development is to take place.

In November 1961 H.M.S. *Owen* left Aden and after carrying out a scientific traverse arrived at Lamu Harbour in Kenya on the 16th. A camp party was established at Shella, tide watching camps at Shella and Mwamba Ziwain, 27 miles to the north, and survey parties were despatched along the coast. Ship and boat sounding proceeded for surveys on scales at 1:50,000 and 1:75,000. The southern part of the survey of the Approaches to Lamu, Manda and Patta Bay was completed, and the coastline between Tenewe and Ras Mbiongo was surveyed and tidal streams off Ras Mbiongo were observed. Offshore sounding was progressed northward and eastward, and the camp party completed the local survey.

After an interlude at the Seychelles and Christmas at Mombasa, H.M.S. *Owen* returned to Lamu to continue the surveys, which were broken off again from early January until mid March when the ship was in the Indian Ocean. During the second half of March and the first week of April a subsidiary coastal triangulation was carried out from the Lamu and Manda Islands northwards into Manda Bay and eastwards to Sylph Rock and the south coast of Patta Island. Sounding was continued in the approaches to Lamu, Manda and Patta Bays. The boats were employed interlining, bottoming and sketching views while the ship made a great effort to complete the outer part of the survey. Aided by some glorious weather this was finally accomplished just within the allotted time.

It is the policy to revise and modernize the charting round the coast in addition to keeping abreast with incoming new material so that where possible new charts are prepared to replace old and out of date ones. Thus series of charts have been schemed on standard scales and a large proportion of these have already been published, including a number of small scale ones.

Most of the coast of Africa will eventually be covered by a coastal series at a scale of 1:300,000—this scale being varied to 1:500,000 for three of the charts between Cape Vert and Cape Palmas; as maller scale series at 1:1,000,000 will be the largest scale in a few places of open coastline, and general sheets will be produced at 1:3,750,000. Charts at scales of 1:100,000 and larger are produced where necessary.

Thus, during the last five years there have been published: one new chart at 1:3,750,000, covering most of the east coast of Africa, four at 1:1,000,000 (three on the west coast and one on the east coast), six at 1:300,000 (one on the west coast and five on the east coast), one at 1:500,000 on the west coast, two at 1:150,000 of Morocco, one at 1:100,000 of the Canal de Geba, 11 at scales larger than 1:100,000 and two sheets of plans.

The smaller scale charts were partly replacements, incorporating older work as well as new material received from local sources and from foreign Governments. Most of the 1:300,000 series were of Portuguese East Africa and were drawn from Portuguese charts, and the 1:150,000 charts were based on French charts. The larger scales were either from original surveys or from foreign government charts.

In addition to new charts, major corrections have also been made to 47 existing charts. Original surveys or copies of surveys have been received from the South African Government, the Nigerian Ports Authority, South African railways and harbour boards and East African railways and harbour boards. Harbour masters have been helpful in supplying information and occasionally private firms and shipping companies have been able to provide material. In countries under the control of foreign governments the foreign government charts have provided the source material for the British charts. From all this material corrections have been carried out to many large scale plans of ports and rivers, and their approaches and to some smaller scale coastal sheets.

Section D

Air charts

1:1,000,000 scale

Africa is completely covered by the Royal Air Force topographic series, GSGS 4695. A programme for the replacement of this series by new charts, each covering the area of four of the GSGS 4695 charts, is just starting and is scheduled for completion in 1969. The new series is known as the Topographic Navigation Chart (TNC) Series. It is a new compilation and among new features of the specification is the use of hill-shading as means of emphasising relief.

1:500,000 scale

Partial cover, confined to the North African coastal belt and part of the Somali Republic, is provided by the Royal Air Force topographic series, GSGS 4715. A programme for the replacement of this series and extension of cover southwards to latitude 28° N is now planned. This new series, known as the Topographical Tactical Chart (TTC) series is approximately the same sheet size as the new charts at 1:1,000,000 scale and the specification will also include hill-shading for emphasis of relief.

Plotting charts

Complete cover of Africa is provided by the Royal Air Force Mercator Navigation Chart series at scales of 1:3,000,000 and 1:6,000,000.

Appendix 1

(*a*) SURVEY PHOTOGRAPHY FLOWN BY THE ROYAL AIR FORCE, 1946-1953

Country	*Area*	*Date started*	*Date completed*	*Scale at sea level*
Basutoland	Whole country	1950	1952	1:40,000
Bechuanaland	South-eastern area	1947	1950	1:40,000
The Gambia	Whole country	1946	1946	1:30,000
Ghana	Northern and Eastern areas	1948	1951	1:30,000
Kenya	Whole country	1946	1952	1:30,000
	Northern area	1956	1960	1:80,000
	South-western area	1960	In progress	1:50,000
Libya	Whole country	1958	1962	1:60,000
Nigeria	Northern half	1949	1951	1:30,000
Northern Rhodesia	Central and Eastern areas	1947	1951	1:30,000
	Northern and Western areas	1959	In progress	1:80,000
Nyasaland	Whole country	1947	1951	1:30,000
Sierra Leone	Whole country	1951	1951	1:30,000
Somalia				
(former British Somaliland)	Whole country	1951	1952	1:30,000
(former Italian Somaliland)	Whole country	1960	1960	1:60,000
Swaziland	Whole country	1947	1947	1:40,000
Tanganyika	Southern half	1947	1952	1:30,000
	Coastal strip	1961	1961	1:60,000
	Four areas	1962	In progress	1:80,000
Uganda	Whole country except for extreme south-west	1947	1952	1:30,000
Zanzibar and Pemba	Partial cover	1947	1947	1:14,400

(*b*) SURVEY PHOTOGRAPHY FLOWN UNDER CONTRACTS ARRANGED BY THE DIRECTORATE OF OVERSEAS SURVEYS, 1951-1963

Country	*Area in square miles*	*Date*
Basutoland	15,850	1961
Bechuanaland	26,073	1951
	16,120	1956
	25,680	1957
	40,550	1961
	21,170	1962
The Gambia	2,280	1956
	32	1961
Ghana	5,880	1951-1952
Kenya	2,200	1953
	27,000	1954-1955
	3,360	1955
	17,270	1955
	3,216	1956
	7,900	1958
	3,570	1958-1959
Nigeria and former British Cameroons	17,225	1956
	9,838	1957
	18,700	1958-1959
	3,190	1959-1960
	4,505	1961
	5,900	1962
Northern Rhodesia	700	1954
Nyasaland	1,320	1955
	16,440	1962
Sierra Leone	11,393	1956
	10,930	1958
	13,700	1958-1959
	7,660	1959-1960
	1,732	1961
	1,780	1961

Appendix 1 *(continued)*

Country	*Area in square miles*	*Date*
Swaziland	7,950	1961
Tanganyika	20,173	1953
	13,000	1954-1955
	11,800	1955
	12,480	1956
	3,980	1957
	13,300	1958
	13,955	1960
	12,500	1961-1962
Uganda	950	1953
	9,300	1954-1955
	16,570	1955
	3,000	1956
	21,000	1960
	13,820	1961-1962
	13,000	1963
	13,400	1960
TOTAL	543,342	

Scale mainly 1:30,000 or 1:40,000.

Appendix 2

PRODUCTION OF BASIC MAP SERIES

Country	*Scale*	*No. of sheets required to cover the whole country*	*Total produced in U.K. as at 30 April 1963*	*In production 30 April, 1963*
Basutoland	1:50,000	60	60 (47*)	21 (21*)
Bechuanaland	1:125,000	223	90	—
The Gambia	1:50,000	30	30	2 revised
Ghana	1:50,000	486	57 (47*) and 7 compilations	40 (26*)
Kenya	1:50,000	819	175 (67*)	42 (20*)
Mauritius	1:25,000	14	13 (13*)	—
Nigeria	1:100,000	—	15	—
	1:62,500	—	50	—
	1:50,000	1,269	140	169
Northern Rhodesia	1:50,000	1,118	354 (76*)	44 (11*)
Nyasaland	1:50,000	165	113 (19*)	60 (1*)
Pemba	1:63,360	1	1 (1*)	—
Seychelles	1:10,000	11	2 (2*)	9 (9*)
Sierra Leone	1:50,000	118	39	66 (5*)
Somalia (former British Somaliland)	1:125,000	68	68	—
Swaziland	1:50,000	31	31 (31*)	—
Tanganyika	1:50,000	1,239	314 (106*)	60 (42*)
Uganda	1:50,000	328	187 (146*)	80 (65*)
Zanzibar	1:63,360	2	2 (2*)	—

* Contoured or formlined either completely or in part.

MAP COMPILATIONS UNDERTAKEN BY THE ASSOCIATION OF AFRICAN GEOLOGICAL SURVEYS[1]

Since its foundation in 1929, the Association of African Geological Surveys has undertaken several projects of continental synthesis, notably map compilations. These projects have been achieved with the co-operation of official geological surveys and, since 1956, that of major mining companies.

The first project to be completed was a geological map of South-equatorial Africa, a region where no geological synthesis had as yet been compiled. This map was published in 1933.

After this first experience, the Association undertook a geological map of the entire continent on a 1:5,000,000 scale. The nine sheets of this map were published separately between 1938 and 1952. The complete map was presented at the International Geological Congress held in Algiers in 1952.

A new map on the same scale is now being printed. This map cannot be considered as a second edition, for there remains of the first map but the essential lines of the topographic base and a few geological boundaries in those rare regions where no recent observations warranted the drafting of new documents. It is common knowledge that after World War II a great effort was made in geological reconnaissance throughout nearly all Africa, filling gaps, defining boundaries and chronological successions. Simultaneously, meetings of the Association of African Geological Surveys became a biennal occurrence, instigating confrontations which mitigated the difficulty of problems of coordination.

On the other hand reconnaissance results gave rise, after 1954, to the publication of regional syntheses, the first step towards a new continental synthesis.

The indispensability of this new synthesis became apparent at the meeting of the AAGS held during the 20th Session of the International Geological Congress in Mexico, in 1956; it was then recommended that the nine sheets of a new edition be published simultaneously and not successively—as in the case of the former edition—in order to achieve homogeneity of both presentation and information.

However, sheet 3 was published in 1959 on account of the exceptional character of the information it contributed to the geology of the Middle East, of which a first synthesis had been compiled by L. Dubertret in Collaboration with numerous geological departments, both official and private.

Drafting of the other sheets was effected during 1958, using the 1:1,000,000 and 1:2,000,000 maps published subsequently to the first edition. Numerous manuscript documents, some of which have been recently published, enabled these basic documents to be brought up to date.

The draft of sheets 4, 5, 6 and 8 were presented and discussed at the meeting held by the Association during the International Geological Congress at Copenhagen (1960). First proofs of the same sheets were discussed at the Association's meeting in Lusaka (August 1962) and first proofs of all nine sheets were ready for the Plenary Session of the Commission for the Geological Map of the World held in Paris (December 1962).

General agreement on co-relation of the various Precambrian formations was obtained through these displays as well as by individual contracts made by the General Convenor with African geologists in Paris and Brussels.

In brief, the new geological map of Africa, 1:5,000,000 can be said to demonstrate the great progress in the knowledge of the continent made up to the end of 1960 and in certain cases, 1961, summarizing the knowledge obtained by research organizations, members of the Association.

The simultaneous publication of the nine sheets presented a financial problem which has been resolved with the assistance of UNESCO.

In the years between the publication of the two editions of the geological map, the Association published a structural sketch map, 1:10,000,000, which required six years of discussions before achieving a draft which corresponded to the average opinion of African geologists.

The present programme of the Association includes the following projects which will be undertaken with the assistance of UNESCO:

A tectonic map of Africa, 1:5,000,000;

A mineral deposit map, with a special geologic base, on the same scale;

A geological map on a 1:10,000,000 scale in three sheets, to be incorporated in the Geologic World Atlas.

[1] The original text of this paper, contributed by the Association of African Geological Surveys, appeared as document E/CN.14/CART/82.

INTERNATIONAL MAPS PUBLISHED BY CCTA/CSA[1]

By Dr. A. C. Evans

The Commission for Technical Co-operation in Africa and the Scientific Council for Africa have always taken a lively interest in cartography in view of its obvious value to governments of newly independent nations in many fields. I need only mention climatology, agriculture, hydrology and aviation to stress this point.

Base maps of Africa

The first Joint Project undertaken by CCTA was to

[1] The original text of this paper, contributed by the Commission for Technical Cooperation in Africa, appeared as document E/CN.14/CART/33.

produce a Climatological Map of Africa. This task was entrusted to Professor S. P. Jackson of the African Climatological Unit of Witwatersrand University who has a high reputation in this field. At the same time the Commission was being urged to produce a large number of other maps. Professor Jackson undertook to try to find a simple way of providing facilities for these maps to be produced without wasting the resources of national cartographic agencies. To this purpose a series of base maps was prepared. The following are the essential features of the scheme:

(*a*) The continent was divided into six sheets (1:5 million) in such a way that the larger countries were shown on the same sheet and that all sheets would fit together to make a single map. The projection was equal areas;

(*b*) A smaller sheet (1:15 million) containing essentially the same detail;

(*c*) A smaller sheet still (1:30 million);

(*d*) A plan has been made to divide the graticules into single and quarter-degree squares. These sub-divisions are printed in non-photographic blue for ease of plotting;

(*e*) A single outline map on a scale of 1:10 million with no detail has been prepared.

Place names and details have been checked so far as possible by official services. Many are already in use in different parts of Africa and they will be valuable bases for future projects in mapping the distribution of the many factors of interest to planners.

Climatology

The Climatological Atlas contains 56 maps to the scale 1 in 5, 1 in 15 and 1 in 30 million giving useful information on rainfall, humidity, temperature and isolation. This Atlas is also in effect a regional experiment. The maps are of interest first as maps of Africa and second as new specimens of meteorological cartography.

During the initial stages of preparation a number of technical problems both meteorological and printing arose, such as a suitable method of expressing rainfall since in many areas the variation in rainfall is at least as important as average values. For temperatures it had to be decided whether isotherms should represent actual surface temperature or if these should correspond to a standard level. Also, since mean annual isotherms are difficult to interpret, it had to be decided whether isothermal maps should be limited to certain months of local significance. For humidity the mean humidity mixing ratio was decided on since from it various other parameters could be derived. Variety of printing, transparency of colour, adequacy of relief representation and so on had to be decided. In this way, the climatological atlas of Africa can be regarded as an important technical contribution towards the eventual production of a World Climatological Atlas.

UNESCO ACTIVITIES IN CONNEXION WITH TOPICAL MAPPING[1]

Report by Dr. M. Batisse

In the course of its scientific work UNESCO has been led to take an increasing interest in the preparation of topical maps for the description of natural surroundings: geological maps, soil maps, vegetation maps, hydrology and the like. This interest was first aroused when the need for climatic classifications of such areas became apparent in connexion with research work on arid zones. Subsequently, it was found necessary to present the conclusions arrived at in studying the various regions in the form of syntheses that could be understood by all concerned. Thus a small-scale map was published in 1952, containing a world classification of the arid and semi-arid homoclimates (based on Thornthwate's conceptions) and a cartographic study was made of the potential evapotranspiration of South-West Asia.

The work on topical mapping done by UNESCO is based on the following notions:

(*a*) An agreement on the classifications and nomenclatures used in small- or large-scale maps is indispensable for any understanding between the experts of the different countries and any general progress in the various sciences of the earth. Such standardization must obviously be envisaged on a world-wide and not merely a local or regional basis, and it should be sought in every subject in which it does not yet exist. With this in view, an *International Legend of Symbols and Signs for Hydro-geological Maps*[2] was recently issued; it will permit a minimum degree of uniformity in the presentation of maps on underground waters, both on a large and a small scale. Similar agreement is sought in other sectors, such as vegetation and geo-morphology;

(*b*) Whereas the plotting of large-scale maps is primarily a national affair, the preparation of small-scale topical maps (on the scale 1:5,000,000 for instance) can be undertaken in general only on an international basis because such maps concern several countries which must be requested to supply the most up-to-date information. The small-scale topical map may thus be termed a means of international co-operation;

(*c*) The preparation of small-scale topical maps leads to important scientific progress; in the first place, such work reveals the gaps in the documents to hand, it implies the existence of a minimum degree of agreement concerning the means of representation adopted, and that is in itself a source of progress in ideas; it enables the mistakes which have come to light to be corrected; it constitutes the most telling synthesis that can be made of knowledge concerning a given science or a given region, which makes it a remarkable instrument both for research

[1] The original text of this paper, contributed by UNESCO under the title "Activités de l'UNESCO relatives aux cartes thématiques" appeared in French as document E/CN.14/CART/94.

[2] UNESCO publication No. NS/NR/20, January 1963, available on request.

and for instruction; lastly, although it does not quite fulfil the requirements of persons dealing with specific and localized questions of development, for which much larger scales are necessary, it provides the general outline of their activities and indicates possible comparisons with other regions which are very useful at the experimental as well as at the plotting stage.

These conceptions are quite obvious to cartographers, but to recall them here will serve to show the scientific as well as what might be called the philosophic reasons why UNESCO is interested in the classification and legends of topical maps and the plotting of such maps on the samll scale.

In practice, it is in promoting the meeting of qualified experts, facilitating the task of the competent international scientific organizations, and publishing maps and other publications that UNESCO makes its main contribution to cartography. The organization of regional courses and the award of fellowships also enable UNESCO to make known the methods recommended for any particular subject, such as, for example, hydrogeology.

In the particular case of Africa, the following small-scale developments or projects are being carried out:

I. Geology

1. *Geological map* of Africa on the scale 1:5,000,000—of which the maquette has already been exhibited in Nairobi—together with an explanatory brochure, issued by the Association of African Geological Services (ASGA), is published jointly by the Association and UNESCO and will be on sale shortly.

2. *Tectonic map of Africa* on a scale of 1:5,000,000 is in course of preparation, jointly with ASGA.

3. Map of the mineral resources of Africa on a scale of 1:5,000,000, with geological base, is being prepared jointly with ASGA. The maquette will be ready at the end of 1964.

4. The sheets covering Africa for the *World Geological Atlas* on a scale of 1:10,000,000 which is being prepared jointly by UNESCO and the International Commission on the Geological Map of the World will be ready, as far as the maquette stage, by the end of 1964.

5. A map on the scale 1:10,000,000 showing the *situation of the principal mineral resources of Africa* is annexed to the "Survey of the Natural Resources of the African Continent", which has just been published by UNESCO.

II. Pedology

6. UNESCO and FAO have jointly undertaken the preparation of a *World Soil Map on the scale 1:5,000,000.* This work raises the delicate matter of the correlation of one continent with another as well as that of nomenclature. As a first step, an attempt has been made to encourage the publication of the maps of the continent already in preparation. The soil map of Africa produced and published by CCTA forms part of this general plan.

III. Climatology

7. "*Bioclimatic map of the Mediterranean region*" on the scale 1:5,000,000, covering the northern part of Africa as far, approximately, as the 20th parallel, has just been published, together with an explanatory booklet, jointly by UNESCO and FAO. This map is accompanied by inset maps on the scale 1:10,000,000 showing other regions of the world with a similar climate, particularly South Africa. This map is an attempt to make an empirical classification of climates with mild and wet winters and dry summers from the point of view of their effect on plants.

IV. Vegetation

8. *Vegetation map of Africa* (south of the Tropic of Cancer) on the scale 1:10,000,000, produced under the "Tropical humid zone" programme of UNESCO, was published in 1959 by the Oxford University Press. A new map, covering the whole of Africa, is under consideration.

9. *Vegetation map of the Mediterranean region* on the scale 1:5,000,000, completing the bioclimatic map described above and using the same topographical base, is under preparation and will be published, with a booklet, in 1964.

Part III

STUDIES, REPORTS AND COMMUNICATIONS

AGENDA ITEM 7

Development of cartographic services

ROLE OF THE CARTOGRAPHIC SERVICE IN THE OFFICE DE LA RECHERCHE SCIENTIFIQUE ET TECHNIQUE OUTRE-MER[1]

1. The purpose of the Office de la recherche scientifique et technique outre-mer (ORSTOM), which was set up in 1943, is:

To determine the basic data of natural and human environments;

To undertake and develop all kinds of fundamental research relating to plant and animal production in the non-temperate areas of the globe, and more particularly in the inter-tropical and arid zones.

2. This brief mention of aims gives but a bare idea of the tasks which the 650 scientists and technicians of ORSTOM have had, and still have, to confront. The scientific disciplines and techniques are numerous and nearly all have marginal interests in common. The organization which enables this system to function without watertight compartments is composed of the following three main elements:

(*a*) A vertical scientific organization of disciplines or groups of related disciplines for the training of research workers, preparing research programmes, checking the progress and results of the work undertaken, whatever the origins of such work;

(*b*) A horizontal or geographic organization which, in the institutes, centres and missions, whether permanent or temporary, groups and administers the research workers of ORSTOM by co-ordinating their activities. These widely different working groups rely to a great extent on the Scientific and Technical Centre of ORSTOM (Bondy, France), which serves, in a way, as their "supply base".

(*c*) Services, including a central documentation service, common to the first two.

The cartographic service of ORSTOM (thematic cartography) forms part of the last named.

3. These very general considerations were necessary in order to allow a proper understanding of the position occupied by this service in a multi-purpose organization engaged in fundamental research in the inter-tropical zone for the last twenty years.

4. There are few scientific areas in which ORSTOM research workers are engaged that do not require the preparation of maps. The following disciplines, in particular, however, manifest their results wholly or partially in this manner, or else demand the preparation of certain thematic maps for their further progress:

Human sciences (geography, demography, sociology, ethnography);

Pedology;

Geophysics;

Medical and veterinary entomology; and

Phytogeography.

5. Moreover, each of these general themes cover operations, the very great variety of which is attributable either to the working methods of the research workers or to the ends to be attained in the course of a given programme.

6. Most often, synthetic, small-scale maps, the rate of productions of which is slow, are suitable for fundamental research and the need to process uncorrected data and classify facts; medium and large-scale maps, often very limited in space, more quickly prepared, account being taken particularly of the techniques used, suit directly applied research, resulting very often from agreements with Governments.

7. The practical aspect of these latter studies is made increasingly manifest by the complementary subjects presented by the general *theme* derived from a precise scientific discipline. Thus, the pedologist will emphasize and facilitate the practical interest of his soils map by charts showing the potential and utilization of the soils, and in some cases by geological or phytogeographical diagrams.

8. In the human sciences, the development of ORSTOM's cartography has been as follows:

As long ago as 1944, small-scale diagrammatic maps (1:5,000,000) attempted to synthesize the documentation available at that time in certain areas limited to west Africa (population density, housing, animal breeding, etc.);

Latterly, and particularly since 1950, the field missions and the activities of the centre and institute research workers, both increasing, have leaned towards basic inventory themes (pastoral atlas of Mauritania and Senegal, ethnic and demographic maps, etc.);

Currently, syntheses are being made, based this time on a sufficient number of field studies to justify them: such as the ethno-demographic 1:1,000,000 maps which are to cover the French-speaking central African States.

[1] The original text of this paper, submitted by France, under the title "Rôle du service de cartographie dans l'office de la recherche scientifique et technique outre-mer", appeared in French as document E/CN.14/CART/22.

9. The work of the Cartographic Service of ORSTOM in pedology is particularly important.

10. Here, two principal types of map have to be considered:

(*a*) Depending on the scale and technical and scientific use to which it is adapted, they are:

Synthesis, or general, maps, going from 1:1,000,000 to 1:5,000,000 (sometimes 1:500,000 may be included); they include "syntheses" of fragmentary or provisional knowledge (e.g., the 1:2,000,000 atlas of the Cameroon), as well as nearly definitive complete maps which resume by co-ordinating them, numerous data permitting an accurate general representation of soil groups or subgroups over the whole area of a territory (e.g., the 1:2,000,000 of the Ivory Coast).

Inventory maps, most often regional: they are base documents, for they prepare the way for studies of detail or practical application and also constitute the material that can be used for the syntheses. The most usual scales are sometimes 1:500,000, but more often 1:100,000 and 1:200,000. In some cases the 1:50,000 may be classified under this heading.

Maps of this scale have been prepared in all French-speaking African States and in Madagascar.

Application or detail maps, going from 1:50,000 to 1:5,000 or even to 1:2,000; they relate to small administrative territorial units, rural settlement areas; they are just as much "pocket handkerchief" maps (beds of pool, experimental stations) as maps of vast irrigation surfaces.

(*b*) Depending on their content, the nature of their scientific, technical or practical data, there are *soil maps* proper distinct from maps for *the utilization of lands* which are defined by "their agronomic value characterized by their intrinsic fertility potential, in terms of their possible mode of utilization".

11. In geophysics, maps rely on the results of surveys made by the ORSTOM research workers and technicians at the M'Bour (Senegal), Bangui (CFA) and Lomé (Togo) centres by the missions.

12. The observations bear essentially on gravimetry and magnetism, and, subsidiarily, on the isostatic anomaly.

13. These data contribute to a complete knowledge of the subject, add to the knowledge of the large geological groups and facilitate the use of the compass. Synthesis maps are small-scale (1:5,000,000) and generally monochrome; a very interesting trial in colour represents the + or − variation of g. (gravimetric map of west Africa).

14. Medical entomology maps, which are very closely concerned with the human environment, respond to two main considerations:

To plot the geographic areas and limits of the principal vector insects (*anopheles*, *glossinae*), either by repeated use of symbols or by square degrees;

To represent globally the simultaneous elements or the successive phases of eradication campaigns (of malaria in particular).

15. Whence the publication of maps of the distribution of the *anopheles*, and *glossinae*, at first in a more or less provisional manner within the limits of States, then in printed form for large geographical areas (west Africa, equatorial Africa).

16. In phytogeography, four 1:200,000, maps have been published which are made on much the same principles as those followed by Professor Gaussen; the division sheets of Longa, Thies (Senegal), Bouaké (Ivory Coast), Diafarabé (Mali).

17. Maps on 1:1,000,000 of Dakar and Conakry are at present in the press.

18. Finally, the ORSTOM Cartographic Service must be credited with the preparation of atlases, the first of which, still incomplete, is that of Cameroon.

19. That is a question of syntheses which must subsequently and regularly be brought up to date, but the balance of which in the operational plans and techniques (scales, graphs, etc.), is greatly facilitated as much by the cohesion of the teams of research workers or technicians, both those belonging to ORSTOM and those outside ORSTOM, working in the centres of states, as by that of the central team of thematic cartography.

20. Moreover, it is obvious that the quality and importance of cartographic work depends to a great extent on collaboration between research workers and cartographers. Three methods are used to facilitate this collaboration:

The initiation of the research workers in certain techniques or in certain subjections proper to cartography in the specialized field of each one; this contact is facilitated by the installation of the cartographic service in a scientific centre where research workers of several disciplines are present, or passing through;

Conversely, the initiation of cartographers in certain aspects of the methods of thematic surveys, in the difficulties encountered in field work, by sending some of them on courses of varying deviation in overseas centres or institutes. This method offers in addition, the considerable advantage of giving advanced training to the African draughtsmen or assistant draughtsmen of those centres;

Finally, consideration is being given to the conditions under which some of these draughtsmen or assistant draughtsmen will be enabled to improve their cartographic techniques for the purposes of particular themes (geology, human sciences).

21. In conclusion, mention should be made of the preparation overseas, by research workers of ORSTOM, of thematic maps of a provisional nature, in limited numbers, illustrating or concluding urgent convention work; most often these maps are used again in definitive syntheses. Similarly, many very small-scale maps illustrate articles, studies for specifications or memoranda: they are, for the most part, prepared by the Cartographic Service of ORSTOM.

ORGANIZATION OF A GEOGRAPHIC INSTITUTE IN THE IVORY COAST[1]

By Mr. Gilles, Director of the Geographic Office, Ministry of Public Works, Transport, Posts and Telecommunications

1. In a new country cartography necessarily appears as a progressive work which must be adopted to the rate of growth of a rapidly developing economy.

2. The methodical prospecting of natural resources requires, essentially, a small-scale aerial photographic coverage, from which can be derived fairly quickly a 1:200,000 map adequate for the study of preliminary plans and equipment programmes.

3. At the practical application stage the technical services are more demanding and call for a detailed contour map, on a minimum scale of 1:50,000, capable of serving as a base for accurate studies.

4. Finally, in a fully expanding economy the map tends to become a compendium of information, in strikingly diagrammatic form, and a real inventory of existing wealth, most usually found in the very large-scale cadastral maps.

5. The Government of the Republic of the Ivory Coast clearly appreciated the importance of the map as a factor of economic development when it decided to establish a geographic institute at Abidjan and at the same time to study the measures for providing the Ivory Coast with a modern cadastre.

6. The purpose of this note is to explain the leading ideas of the equipment programme of the Institut géographique (Geographic Institute) of the Ivory Coast, the stages by which it is expected to be put into effect, and to describe the tasks it will be assigned.

The equipment programme of the Institut géographique of the Ivory Coast

7. The equipment programme was studied in 1961 on the basis of the following guiding ideas:

(*a*) The Institut géographique would be equipped to carry out, on its own, all cartographic operations except aerial photographic coverage. It would thus be responsible for the geodetic network (geodesy, astronomy, precision levelling) required for surveys and stereopreparations, plotting and the rectification of photographs, and, finally, for drawing and printing maps.

(*b*) Since the cost of the proposed operation is fairly high (approximately CFA 300 million) it was agreed that this programme would be carried out in successive stages over a comparatively long period, about five or six years, according to the resources available to the Ivory Coast and possible foreign assistance it might obtain.

These delays in the work were permissible because the Institut géographique national français (French National Geographic Institute), which was responsible for Ivory Coast cartography, would for some years be able to continue supplying the most urgent needs until the Institut géographique of the Ivory Coast was in a position to assume responsibility for the work.

(*c*) At one stage a proposal had been made to set up a large photographic and cadastral establishment to coordinate the work of the Institut géographique and the Service topographique (Topographical Service). This move ran into certain practical difficulties and was finally abandoned.

The proposed organization must therefore, in the immediate future at least, keep the two services separate, for their operations are differentiated by the somewhat conventional idea of the scale of the survey:

The Service topographique is responsible for all work on scales equal to or above 1:5,000;

The Institut géographique is competent to perform all work on scales smaller than 1:5,000. It is also responsible for establishing first and second order geodetic nets (astronomy, geodesy, levelling).

(*d*) An important decision was made in 1961 with respect to the staff of the Institut géographique and the Service topographique for a single statute was adopted giving the staff of the two services absolutely parallel gradings.

8. The question of the training of Ivory Coast officials and the provision of advisers was settled with the assistance of the Institut géographique national français. The Institut agreed to provide, at its École nationale des sciences géographiques (National School of Geographic Sciences) in Paris, two-year training courses for higher grade technicians. As a temporary measure, it seconded a number of officers to constitute the superior ranks of the new service during the period of organization and the initial stages of the work.

9. In application of these principles, the plan drawn up provided for the building up of the institute and consisted of a preparatory period and three successive equipment phases.

10. During the preparatory period a Geographic Office, the first element of the future service, was opened in 1961 responsible for compiling documentation and information, for proceeding with the studies and putting the programme into effect. This office administered a photo-map library, to which two small training workshops (drawing and assembling of aerial photographs) were added at the end of 1962.

11. The plan proper was divided into three phases in which the construction of the buildings and the installation of the equipment would be included.

12. In 1962 credits for studies relating to the first two phases of the projects were opened, together with a programme authorization relating to the first phase (erection of buildings and equipment) to be launched in 1963.

13. The building programme consisted of:

[1] The original text of this paper, submitted by the Ivory Coast, under the title "Organisation d'un Institut géographique en Côte-d'Ivoire", appeared in French as document E/CN.14/CART/28.

A technical building divided into two blocks, I and II, connected by a central hall.

A printing shop, separate from, but in connexion with, the above building.

14. Upon completion of the programme the various sections were to be distributed between the two buildings as follows:

First phase. Central hall and block I. Area 862 m².
Distribution of sections:
Management, information, administration;
Map drawing;
Photogrammetry: plotting and rectification workshops.

Second phase. Block II. Area 697 m².
Field work section (geodesy, levelling, checking);
Equipment store;
Map store;
Garage.

Third phase. Printing shop. Area 1,040 m².
Photomechanical reproduction workshops;
Press and machine workshops;
Printing shops.

15. The first two phases correspond to the division in time of the achievement of a homogeneous whole—the technical building. The third phase represents an operation distinct from the first two, with no necessary connexion with them and postponable if need be.

16. The equipment must also be installed in three phases parallel with the erection of the buildings:

First phase: standard equipement used in geodesy, topography, photogrammetry and drawing.

Second phase: installation of heavy material (plotting, rectification) and standard supplementary material.

Third phase: installation of photomechanical reproduction offset equipment.

17. Although placed at the end of the second phase in block II, the first elements of the "field work" section could be installed from the beginning because the draughtsmen's section and the photogrammetry section will not be fully developed until all the equipment has been installed.

18. The training of Ivory Coast staff has been expedited and the first five officials trained at the National School of Geographic Sciences in Paris joined Abidjan in January 1963. Seven other officials, at present training in Paris, will complete their courses at the beginning of 1964. The middle and lower grade staff receive in-service theoretical instruction which will be completed by practical training in the workshops of the Service.

Mission of the Ivory Coast Geographical Institute

19. The Institut géographique national français has since 1945 carried out in the Ivory Coast extremely important geographic work in which priority was given to small and medium-scale maps.

20. The Institut géographique of the Ivory Coast which will succeed the French Institute, will assume responsibility for a whole geographic capital which must be utilized and safeguarded, and will have to complete the work now begun.

21. It will also, however, have to embark on large-scale work which will open up to it an entirely new branch of activity.

22. We shall now examine successively first the small- and medium-scale work, and then the large-scale work, which will devolve upon the new Institute.

Small and medium-scale

23. The Ivory Coast Institute will have at its disposal valuable photographic documentation consisting of the 14,000 plates of the general 1:50,000 systematic coverage of the whole of the Ivory Coast.

24. From the Institut géographique national it will inherit a complete set of base equipment consisting of 250 astronomical points and precision levelling for 5,000 kilometres (2,000 guide marks).

25. Its task will be to preserve these points, which are particularly valuable in so far as the levelling net is concerned and which are of sufficient precision to act as a base for all future vertical control work.

26. The astronomical control net, designed and brought into being solely for small and medium-scale surveys, cannot act as a base for large-scale precision surveys.

27. The Ivory Coast Institute will have to ensure the revision and reissue of the general map on the scale 1:200,000, in thirty-eight of one degree square. This map is already in a very advanced stage of production but some sheets, which are now ten years old and which were compiled from "trimetrogon" photographs will have to be recompiled from recent photographic coverages.

28. The new map on scale 1:50,000 compiled from vertical photographs at present numbers some hundred plotted sheets, mainly covering the coastal regions, and forty new sheets are in preparation.

29. It will take nearly 450 sheets to cover the whole of the Ivory Coast and this long-term work will be one of the main tasks of the Ivory Coast Institute.

30. The work mentioned in the above paragraphs already represents a considerable task but does not give rise to great difficulties, for it involves well developed techniques, the methods of which have been tested, and for which all the base planimetric and altimetric networks are already in place.

31. The situation with respect to large-scale surveys is not so favourable and raises, as will be seen, more delicate questions.

Large-scale surveys in the Ivory Coast

32. So far there is in the Ivory Coast no over-all network determined with the precision necessary for geodetic controls and which could serve as a base for homogeneous large-scale surveys.

33. This situation is mainly attributable to the presence of the great equatorial forest which, in a mainly flat country, would have necessitated triangulation on raised beacons, obtainable only at the price of long delays and prohibitive cost price.

34. Large-scale work has indeed been carried out by

the Service topographique and certain technical services, but it was always done locally, based on small triangulations calculated on the plane, sometimes even without accurate base measurement.

35. These methods save the trouble of making the primordial geodetic network but necessarily result in a multiplicity of mediocre precision surveys of limited, unconnected areas.

36. The amendment of the land laws at present under consideration will be directed towards producing a modern cadastre and will undoubtedly very shortly lead to entirely different views on the matter. Obviously, a regulation under which land titles would constitute proof of ownership will be in contradiction with survey methods which guarantee neither precision nor uniformity.

37. Very fortunately, just at the time when the question of determining a homogeneous supporting network, computed with geodetic precision, is being reconsidered, technical progress has supplied surveyors with new means, such as electromagnetic distance measuring devices of the tellurometer or distomat type. These devices determine very accurately the length of the sides of a polygon, the angles of which can be measured on the theodolite; and the azimuths can be corrected by astronomical observations at regular intervals.

38. Sides averaging two or three kilometres in length should, in savannah areas, fairly easily yield 1:50,000 precision. In forest region precision will certainly be lower than this figure but will still be permissible if all precautions are taken to ensure the best orientations.

39. These methods certainly provide a solution to the difficulties encountered in the Ivory Coast and will lead to former methods being abandoned in favour of one of the following two systems.

40. Under the first system it might be possible to plan in the Ivory Coast a small number of centres of variable areas, unconnected with each other. Each centre would have its own zero point, a precise direction and a scale guaranteed at about 1:50,000 on the tellurometer. This solution would render the main control unnecessary but does not give any hope of the unlimited extension of the centres in the future.

41. Under the second, far preferable, system steps must first be taken to effect, by closing the angles, a series of essential polygons, representing approximately 6,000 kilometres of total development, entirely computed and adjusted for the whole country. This work of far-reaching scope could be effected within a few years, and that would be far less than the time needed for an essential triangulation of the same extent.

42. This network would then serve for the installation, at any point whatever of the territory, of complementary points for which the classical triangulation method on suitable terrain or the polygonation method in forest areas would be used. In this way a homogeneous net, calculated in a single system for the whole Ivory Coast would be obtained, to serve as the basis for all future surveys of the Geographic Institute and of the cadastre for very many years.

43. The decisions of principle taken on this matter will be binding for future work and cannot be modified subsequently. They must, therefore, be studied and planned in relation to the prospects of the economic development of the country and not just based on immediate and changing needs.

NOTE ON THE ORGANIZATION OF TOPOGRAPHICAL SERVICES IN WEST AFRICA[1]

1. The object of this paper is to arouse discussion on a question of topical interest in Senegal and in a number of other developing countries in west Africa: that of the remodelling of the former French West Africa Topographical Service to meet present conditions.

2. The various stages of the work and organization of the Topographical Service were clearly closely linked to the evolution of land policy during the period of French occupation.

3. During the years between 1865 and 1932 attempts to introduce the idea of land ownership as defined in the French Civil Code came up against what might be termed a natural collectivism on the part of the tribe, the clan or the family. "The land cannot belong to the individual", the notion that private ownership was solely the reward for work. The producer has the right to enjoy certain benefits (fuelwood, crops and certain dues). The head of the family or the political or religious chief has the right of management, but the land is common property.

4. Surveys carried out during this period were limited to a series of isolated boundary markings, and the topographical offices attached to the Conservation foncière (Land Conservancy Office) had little else to do than to work on the grounds of the land registry office.

5. The progress made in the registration system (begun in 1906) did not, however, succeed in improving the situation. The complexity of the problem resulted in a diversity of régimes:

(*a*) Property held without title deeds according to local custom;

(*b*) Property held according to custom, but of which the beneficiary rights had been recognized (decrees of 1925 and 1955) with or without the addition of the right of disposal;

(*c*) Property held under the Civil Code;

(*d*) Registered property.

6. In view of this situation and of the many criticisms, it was thought at one time that it would be advisable to make registration obligatory, taking into account the increasing number of applications; further, the legal advisers considered it the most appropriate way to hasten land registration.

[1] The original text of this paper, submitted by Senegal, under the title "Note sur l'organisation des services cartographiques en Afrique de l'Ouest", appeared in French as document E/CN.14/CART/59.

7. Among the psychological difficulties encountered, the most important was the lack of a cadastral survey, for only registered lands had been charted. In order to make any progress, therefore, this difficulty had to be overcome.

8. This situation was partly responsible for the splitting up of the Topographical Service into regional divisions closely linked to the divisions of the Conservancy Office, but remaining under the supervision of the Ministry of Public Works.

9. To make a cadastral survey is a monumental undertaking. Requests for financing the surveying and mapping involved have not always been well received by assemblies and political circles because their incidence on the economic situation is indirect and their results are not discernible by those who do not belong to the profession.

10. This has naturally led the Ministry of Public Works to become the first and chief customer of the Topographical Service. The lack of liaison with the Geographical Service widened in proportion as it became easier for these regional divisions (on account of their relatively large staff) to absorb the work of fixing boundaries and parcelling out small holdings, and during that time the question of a cadastral survey remained unanswered.

11. A debate in the National Assembly in 1958 on the reorganization of the Ministry of Public Works and Transport ended in favour of:

The establishment of a cadastral survey as being indispensable for government plans for the rural sector.

A unified topographical service directed by a central office and a technical section with sufficient staff to coordinate the work of the divisions and to provide them with staff according to the volume of the work planned and its urgency.

12. Before 1958, therefore, the Service passed through two phases:

In the first phase the Topographical Service was simply an office of the State Lands.

In the second, it became a subsidiary service of the Ministry of Public Works, whilst still being closely bound to the Service des domaines (State Lands Department).

13. At present, the tendency is towards autonomy—a unified service centralizing all topographical work.

14. The present organization comprises 30 Senegalese land surveyors, 4 Senegalese senior land surveyors and 10 technical assistance experts consisting of 4 engineers and 6 surveyors.

15. Needs have grown. Although a rural land policy has not yet been formulated in detail, nevertheless the number of land utilizers has increased. The short-term programme of work is divided into three parts:

(*a*) (i) Maintenance of existing cartographic activities;
(ii) Structure and general organization (for future cadastral and large-scale maps);

(*b*) (i) Cadastral plans of towns;
(ii) Survey plans of public interest;
(iii) Urbanization and improvement plans;

(*c*) Land policy and property surveys.

16. What are the difficulties to be encountered and what are the chances of fulfilling such a programme?

17. The difficulties may be summarized under three headings:

(*a*) A basic frame work must be produced before the rest of the work can be carried out.

This will entail a fairly large capital outlay. It is well known from experience that the general public is incapable of understanding the purpose of spending large sums on projects of which it cannot see the immediate results;

(*b*) This leads to abandoning the idea of a basic scheme, in favour of producing expansion plans which are the only documents a politician can present to his electors.

It is not profitable to produce a series of plans in urban areas from isolated surveys, the linking together of which may be a more costly undertaking than the production of a general survey, studied in advance and carried out section by section.

It is not profitable either for Senegal, which has passed an average of five surveyors a year for the past three years out of the school (and this rate will probably be sustained, if it is not increased) always to appeal for help to the *entreprise*. It would be better to postpone certain operations and thus allow a better organization of the Service (supply of equipment and improvement of personnel).

(*c*) The surveyor of the French West African type service was trained and worked strictly in land investigation. The total lack of collaboration between the Service géographique and the Service topographique means that quite naturally the present national services in west Africa lag behind in methods of ground surveys, for as regards photogrammetry they had received neither training nor equipment.

18. The reform selected and advocated in Senegal includes the following points:

(*a*) Centralization of all work;

(*b*) Establishment of a solidly organized photogrammetric office to act as a connecting link between all sectors of work (map, cadastral plans, land operations);

(*c*) Regional divisions, including:

Mobile teams from the Central Office;

Regional teams for local work;

(*d*) Advanced training of surveyors by means of courses at centres:

Of cadastral survey;

Of photogrammetry.

19. International co-operation may therefore be fruitful for the organization and development of national services. The stability of States and individuals depends entirely on land ownership. No State can afford to neglect any longer an accurate inventory of its properties. The so-called under-developed countries are only beginning to take an interest in the matter, but in those countries it is particularly important because of the spirit of independence of the individual and his personal claims, and also because of demographic growth. Quite naturally, therefore, the matter is connected with the question of the settlement of populations.

20. The organization and development of national

services in west Africa may be ensured in the following stages:

Establishment by the United Nations of an advanced training centre in west Africa. This centre would be equipped with modern photogrammetric instruments permitting the dissemination of photogrammetric techniques in the interpretation of cadastral and large-scale work. It would be open to all officials working in the national services.

Simultaneous organization by Governments of a photogrammetric section officered by qualified staff (technical assistance) as part of the national services.

GOVERNMENTAL RESPONSIBILITY FOR BASIC SURVEYS AND MAPS[1]

By S. V. Griffith, Adviser on Cartography, Bureau of the Budget, Executive Office of the President, Washington, D.C.

Introduction

1. Certain kinds of basic surveys and maps are a national responsibility and their procurement cannot be left to chance because they are so vitally important to the conduct of many national programmes for social, cultural and economic development and for engineering and scientific purposes. Furthermore, their procurement should be planned and programmed in a well-defined series of sequential operations to assure efficient and economical production, to avoid waste and duplication of effort, and in the sequence needed for agricultural, minerals and fuels, or industrial development. Such a plan and programme might be called a "National Mapping Programme" and it should be designed to meet the most immediate needs for basic information, but should not ignore long-term requirements. The national mapping programme should be prepared by a group of experts and be based upon the needs of the nation for economic development and growth. The programme should be designed to provide reconnaissance surveys and maps in a longer-range programme.

Responsibility for basic surveys

2. In most countries of the world, general purpose surveys, photography, and relatively large scale maps and charts are considered to be a governmental responsibility produced by its own agencies. These include the basic horizontal and vertical geodetic control system; aerial photographs for general mapping purposes which are usually procured from private firms, but the films become the property of the Government from which prints, enlargements and special copies of the negatives can be made as required for surveying, mapping and charting purposes; relatively large scale, nationwide planimetric and topographic maps; general geologic surveys, investigations and maps; soil classification surveys and maps; forest surveys and inventories; range surveys and maps; cadastral surveys and maps; and nautical and aeronautical charts.

3. Such activities as very large scale maps and engineering plans, and airborne magnetometry and scintillometry surveys, are not ordinarily considered to be responsibilities to be performed by governmental agencies, but are usually done under contract with private firms.

Sequential surveying and mapping operations

4. Surveying and mapping operations should be programmed in a series of sequential operations each of which will facilitate the production of the next sequential operation. A geodetic control system should be planned and programmed in advance of all other survey and map operations and done first in areas of the most urgent need.

5. Aerial photographs should be flown soon after the geodetic control is established. Before photography is obtained the geodetic control points should be marked on the ground so that the marked points can be easily identified in the images of the aerial photographs and thereby facilitate map preparation. The scale of the photography should be chosen so as to satisfy the requirements of the subsequent surveying and mapping to be accomplished. After the aerial photographs are obtained, planimetric and topographic mapping should be accomplished as required by the national programmes.

6. Finally, the topical surveys and maps needed to improve the agricultural minerals and fuels, or industrial potential, of the nation concerned should be accomplished.

National standards

7. In many countries surveys and maps are not procured *per se*, but are obtained in connexion with some governmental activity. For example, geodetic control to various accuracies may be made to serve a particular purpose and may or may not be referenced to the national horizontal or vertical data; planimetric and topographic maps may be made to meet particular needs without regard to standards of accuracy, scale, control, format or area covered; and topical mapping may be made on various scales and thereby limit their usefulness for national planning and management purposes.

8. The production of heterogeneous kinds of products should be avoided by establishing, at an early date, national standards for all kinds of general purpose surveys, maps and charts to be produced and thereby make them more useful to the planning and management of national activities.

9. Economy of operation can also be obtained if standardization of techniques, procedures and instrumentation are established. For example, standardization needs to be established for the execution of geodetic control surveys, the procurement of aerial surveys, the preparation of planimetric and topographic maps, the

[1] The original text of this paper, contributed by the United States of America, appeared as document E/CN.14/CART/61.

preparation of topical mapping, and for nautical and aeronautical chart production, so that the techniques, procedures and instrumentation, in so far as practicable within each activity, are compatible and interchangeable.

National programmes

18. No two countries will have the same kinds of national problems to be dealt with. Natural resources, physical environment, conditions of transportation, population and cultures, scientifically and technically trained people, and many other factors, will have to be considered in determining the kinds of national programmes that will need to be developed in order to achieve a sound national economy.

11. In many countries of the world because of large population concentrations, the development of an agricultural base is a first priority requirement and the kinds of surveys and maps that will facilitate agricultural production should be expedited. Other countries, rich in mineral and fuel resources will need to expedite those surveys and maps that will facilitate the exploitation of such resources, including airborne magnetometry and scintillometry surveys and geologic exploration. Still others may determine that conditions are more favourable to industrial development, in which case the surveys and maps that will facilitate such development should be undertaken. And still others may determine that all, or any combination of these, are needed, in which case a careful selection and programming of basic surveys and maps will be required to facilitate those kinds of developments.

Conclusions

12. In some of the less developed, but emerging nations of the world, it may be necessary to provide intensive training of scientists, engineers and technicians in order to be nationally self-sufficient in the procurement of the basic surveys and maps needed for national development. Several of the papers presented by the United States are directed to the subject of education and training. Most of the papers are useful as education and training media in surveying and mapping. Several of them deal with modern methods, procedures and techniques of map production. It is believed that all of them provide important guidelines for the establishment of a comprehensive national mapping programme.

THE ESTABLISHMENT OF A NATIONAL INSTITUTE FOR AERIAL PHOTOGRAPHY, CARTOGRAPHY, AND GEODESY

By Albert L. Nowicki, Chief, Department of Cartography, U.S. Army Map Service, Washington 25, D.C.

[*The original text of this paper, contributed by the United States of America, appeared as document E/CN.14/CART/69. This paper was originally prepared for the United Nations Conference on the Application of Science and Technology for the Benefit of Less Developed Areas, Geneva, 1963. It has been published in volume II,* Natural Resources, Minerals and Mining, Mapping and Geodetic Control, *by the Agency for International Development. This publication is on sale at the Superintendent of Documents, Washington, D.C.*]

MAPS AS A BASIC REQUISITE FOR ECONOMIC DEVELOPMENT

By H. Arnold Karo, B.S., Sc.D., Rear Admiral, USC&GS Director, U.S. Coast and Geodetic Survey Washington, D.C.

[*The original text of this paper, contributed by the United States of America, appeared as document E/CN.14/CART/77. This paper was originally prepared for the United Nations Conference on the Application of Science and Technology for the Benefit of Less Developed Areas, Geneva, 1963. It has been published in volume II,* Natural Resources, Minerals and Mining, Mapping and Geodetic Control, *by the Agency for International Development. This publication is on sale at the Superintendent of Documents, Washington, D.C.*]

PROPOSED REORGANIZATION OF THE LIBERIAN CARTOGRAPHIC SERVICE[1,2]

In a country like Liberia it is not advisable to have more than one service dealing with the same subject. Consequently it will be desirable to centralize the production of maps as far as this is possible in the technical service and the Cartographic Service. To demonstrate this with an example, let us consider the production of forest type mapping for air photographs.

The photo-interpretation must be carried out by forestry engineers, who have specially been trained in the basic principles of photogrammetry and in photo-interpretation. Since they would be producing maps, we propose to consider them as the liaison officers between the Cartographic Service which produced the maps, and the Forestry Service which has the responsibility for these maps as far as the indication of the forest type is concerned. Regarding location of these foresters, there are two possibilities, partly depending on the available facilities. Since they are perhaps the only persons who will really get some experience into photo-interpretation, there is for them no great advantage to be housed with their particular and isolated task in the building of the Forest Service itself. If, on the other hand, a Cartographic Service as we propose is well equipped, these men could just as well work in the Cartographic Service, as they have close contact with photo-interpreters, for soils and geology and with the section making their neat drawings and printed maps. What is needed then is the check of their results by their Chief in the Forest Service.

One item, however, should be made clear: all air photographs belong to the files of the Liberian Cartographic Service and will be made available on a lease basis to another service. After they have been used they must return to the Liberian Cartographic Service which must have a card system on which all photographs are registered, including where they are at a certain moment.

This is logical since in the future organization the cost of all air photography and of the production of prints will be for the account of the budget of the new Liberian Cartographic Service. I do not believe it will be a good system to deal in another way with photographs obtained during 1961, as long as the reorganization of the LCS has not yet taken place, whether the Forest Service has paid for these photographs or not. The fact that in 1961 the Forest Service may pay once a small amount for some photographs which after use, will go to the LCS file, is more than compensated by the fact that later on, all photographic material can be obtained free of charge. Ordering new prints of the photographs 1:40,000 now is only justified by the fact that the Forest Service needs glossy prints and that at present only mat prints are available in the Liberian Cartographic Service file.

If this principle is accepted the Cartographic Service becomes, like for instance in Surinam, a Central Bureau for Aerial Survey, which Bureau provides all the maps for the development projects in co-operation with the technical service as described above for the forestry. The Schermerhorn analysis lists equipment supplies and personnel for a three-year period at a cost of four hundred and sixty eight thousand dollars ($468,000) of which one hundred and eighty five thousand ($185,000) dollars is for an air-conditioned building, and eighty thousand ($80,000) dollars is for a twin engined aircraft. This list is given below:

[1] The original text of this paper, submitted by Liberia, appeared as document E/CN.14/CART/81 and Add.1, under the title "Preparation and reproduction of maps". For better integration into the present report, the original paper has been divided into: "Proposed Reorganization of the Liberian Cartographic Service", "Preparation and reproduction of maps" (see agenda item 15), and "Ten years' achievement of the Liberian Cartographic Service" (see agenda item 6).

[2] Excerpts from the proposal of experts at ITC, Delft, headed by Prof. W. Schermerhorn, and from a team of USAID technicians headed by Mr. Albert Nowicki.

Capital investment	*1961* ($)	*1962* ($)	*1963* ($)
New building for LCS + airconditioning	185,000		
Photographic laboratory equipment	25,000		
Twin engined airplane	80,000		
RC 9 super wide-angle and horizon camera	20,000		
RC 8 wide-angle camera	13,000		
Precision plotting machine		25,000	
Rectifier		20,000	
2 Aviographs B 8		20,000	
3 Stereotopographs Zeiss		10,000	
Printing equipment		23,000	
Tellurometer and instruction	10,000		
Small equipment and miscellaneous	5,000	5,000	
2 Jeeps		5,000	
	338,000	110,000	
CONTRACTS			
Aerial triangulation of small-scale photographs		40,000	
The same of photographs of Monrovia		3,000	
Soils map		50,000	50,000
Geological map		30,000	20,000
		123,000	70,000

Capital Investment	*1961* ($)	*1962* ($)	*1963* ($)
COST OF PERSONNEL			
Photogrammetrists, surveyors + Director	28,000	34,000	42,000
20 draughtsmen	30,000	42,000	45,000
Foreign draughtsmen—surveyor for teaching+housing+transport	7,000	10,000	10,000
Salary of the airplane crew	8,000	15,000	15,000
Photographic lab. personnel	6,000	8,000	8,000
Secretariat and bookkeeping	5,000	8,000	9,000
Maintenance personnel of different level, incl. technician for airconditioning and printing		12,000	15,000
Consultation agreement incl. travelling expenses, etc.	10,000	10,000	10,000
	94,000	139,000	154,000
COSTS OF MATERIAL AND OTHERS			
Insurance of the plane	2,000	7,000	7,000
Maintenance of the plane	1,000	5,000	5,000
Fuel	2,000	4,000	4,000
Photographic material	1,500	4,000	6,000
Material for printing		2,000	2,000
Travelling expenses	2,000	2,000	2,000
Field allowance	1,000	5,000	7,000
Office material + teleph. + mailing costs + electricity + water	1,000	3,000	4,000
Maintenance of 2 Jeeps	500	2,000	3,000
	11,000	32,000	38,000
	94,000	139,000	154,000
Total cost per year for running the LCS as proposed	105,000	171,000	192,000

Recently Mr. Albert Nowicki headed a team of U.S.A.I.D. technicians which made a further analysis of possibilities of resuscitation and improvement of the LCS, which is so vital to the economic development of the country. The Nowicki report recommends a unified or centralized mapping Bureau which would embrace every type of mapping required for the country. In his detailed organization charts he outlines personnel distribution, grading and production flow for an outfit of 347 persons responsible for survey or data collection and mapping. The personnel are as follows: meteorological surveys - 21; hydrological surveys - 10; geological surveys - 30; mining surveys - 14; forestry surveys - 26; soil surveys - 28; general mapping (in which he includes field surveys, photogrammetry, manuscript engravings and reproduction) - 125; records division - 11; planning division - 5; logistics division - 48; library services - 6; personnel office - 9; archives - 2; finance - 9; and headquarters - 3. As the existing situation in Liberia does not combine soils and forestry surveys in the same Department with the other branches, the Nowicki analysis provides for liaison facilities in case the unification cannot be achieved. He outlines a procedure whereby all useful information would be pictorialised on maps at the scales ranging between 1:250,000 and 1:50,000. This programme recommends a building with the space of 53,000 square feet costing $600,000 distributed as follows: meteorology - 3,000 sq. ft.; forestry - 4,000 sq. ft.; water resources - 2,000 sq. ft.; mines - 2,000 sq. ft.; geology - 4,400 sq. ft.; mapping - 21,020 sq.ft.; staff and services - 8,160 sq. ft.; department staff - 2,640 sq. ft.; department headquarters - 80 sq. ft.; soils - 3,360 sq. ft.; miscellaneous (stairways, etc.) - 2,340 sq. ft. He recommends equipment costing $475,000 and an operation's budget of $625,000. Following there prerequisites Mr. Nowicki and his team expect a properly functioning and balanced Mapping Department capable of supplying printed large scale topographic maps of the whole country and having functional elements responsible for collecting, analysing and translating into mapable and statistical form the requirements for the economic development of the country, which would include geological, water resources, economic minerals and meteorological surveys studies and tests; and cadastral and boundary surveys, mapping and title registration.

AGENDA ITEM 8

Training of personnel

MEMORANDUM ON STAFF TRAINING[1]

By The Technical Co-operation Department of the French Ministry of Public Works

1. For the organization, staffing and efficient functioning of cartographic services in the African countries it is essential to have a staff that is qualified, in varying degrees in different branches of basic technology, such as geodesy, topography, photogrammetry and cartography.

2. This qualified staff can, as a whole, be divided into two large and distinct groups, according to the nature of the work in which it is to engage:

A. Activities that are connected fundamentally with work in the field

They are primarily concerned with such scientific specialities as geodesy, topography and photogrammetry.

The three grades generally recognized in this speciality are the following:

(*a*) The highest grade, demanding qualities of conception and control: the *ingénieurs géographes* (geographical engineers) who having already received a high degree of mathematical and scientific training (and already holding the degree of *ingénieur ès-sciences* (scientific engineer)) must then acquire a thorough theoretical knowledge of the different specialities required;

(*b*) The medium grade, concerned in particular with practical operations in the field and with office routine: the *ingénieurs des travaux géographiques* (geographical works engineers), who must receive an appropriate training, having attained a suitable standard of scientific knowledge;

(*c*) The lower grade, which includes operators specially trained in the practical execution of geodetic, topographical and photogrammetric work: the *adjoints techniques géographes* (technical geographical assistants), who receive their training after attaining a basic standard of education equivalent to that of the first part of the *baccalauréat* (certificate of matriculation) in the scientific series.

B. Work connected with the compilation of cartographic documents

(*a*) The *artistes cartographes* (cartographic artists) must not only prove that they have real skill in drawing, but must also have the ability to resolve the difficulties involved in the preparation, compilation and editing of cartographic documents on different scales. Their standard of general education, before they receive their technical and geographical training, must be that of the second part of the *baccalauréat* in mathematics.

(*b*) Finally, the *déssinateurs* (draughtsmen) responsible for executing the cartographic drawings, may receive this training after attaining a lower standard of general education.

3. In any case, the strength of this qualified staff is relatively limited in each State and country of Africa, where in some cases it is reduced to a minimum and no longer constitutes more than a liaison office with the foreign authority, which has been entrusted with the task of carrying out all day-to-day geographical operations, as and when the need is known.

4. For this reason, the measures to be taken in order to train technical supervisory staff of the cartographic services, must be subjected beforehand to very searching scrutiny and must take into account both present structures and their probable development in future years.

5. Moreover, whatever the potentialities—even long-term potentialities—of expansion may be, it seems scarcely conceivable that any single State will be able to organize its own training facilities in all the specialities and at all necessary levels, to meet its requirements.

6. In cartography, as in all other technical work, but doubtless to an even more appreciable extent, any effort to solve the question of obtaining the highest degree of efficiency in the training of higher-grade supervisory staff, must take into account the following considerations:

(*a*) For those at the level of practical technician, up to and including technical assistants, it is necessary that training facilities should exist actually inside Africa, and that use should be made to the greatest possible extent of training centres which already exist, and which teach techniques that are as close as possible to the geographical sciences; and further, that students belonging to neighbouring countries, which are not yet provided with properly qualified centres, should be regrouped, if need be, in these establishments.

(*b*) For those at the higher level, taking into account the very limited numbers required, it seems that with the

[1] The original text of this paper, submitted by France, under the title "Note sur la formation des personnels", appeared in French as document E/CN.14/CART/27.

facilities available as they are at present, it would be reasonable to have recourse to those facilities offered by foreign establishments, and most particularly to those offered by the *École nationale des sciences géographiques* (National School of Geographical Sciences) in Paris, an establishment affiliated to the *Institut géographique national* (National Geographic Institute) of the French Republic.

7. As regards the facilities at present existing in the French-speaking countries of Africa and in Madagascar, the utilization of which may be envisaged in certain circumstances, the following establishments may be cited:

(*a*) The École du génie civil (Civil Engineering School) at Tananarive, under the jurisdiction of the Ministère de l'enseignement technique (Ministry of Technical Training) in Madagascar;

(*b*) The École des travaux publics (School of Public Works) at Dakar, under the jurisdiction of the Ministère de l'enseignement technique of Senegal;

(*c*) The École des travaux publics at Bamako, under the jurisdiction of the Ministère de l'enseignement technique of Mali;

(*d*) The École des conducteurs de travaux (School for Works Supervisors) at Abidjan, under the jurisdiction of the Ministére des travaux publics (Ministry of Public Works) of the Ivory Coast.

8. Finally, and doubtless within a fairly short time, two new establishments are to be set up, namely:

(*a*) The École des agents techniques (School for Technical Agents) at Fort Lamy, sponsored by the Ministère des travaux publics of Chad;

(*b*) The Institut polytechnique (Polytechnic Institute) at Libreville in Gabon, sponsored by the Centre d'enseignement supérieur (Centre for Higher Education) of Brazzaville.

9. All these establishments either have already, or are to have soon, amongst other disciplines, a section for the training of land surveyors.

10. Instruction in these establishments normally extends over a period of four years, after attainment of the standard of *brevet d'enseignement du premier cycle* (BEPC) (diploma of education, first cycle). It tends to give students, and especially those students who take the tests contained in the preliminary examination for expert geometrician, a standard of general scientific education approximately equivalent to that of the *baccalauréat* in elementary mathematics, augmented by well-grounded knowledge of topography.

11. It therefore appears possible, with these satisfactory foundations existing, to envisage additional training in the particular techniques of the geographical sciences by two distinct methods:

Either by providing training actually within these establishments, with the agreement of the different departments concerned, of the additional subjects necessary for each speciality (geodesy, cosmography, astronomy, photogrammetry, geography, geology, graphic techniques, etc.);

Or by the addition in a specialized foreign establishment —and in particular, the École nationale des sciences géographiques (National School of Geographic Sciences) in Paris—of additional training courses to obtain the desired qualification.

12. It remains quite obvious that these indispensable additional subjects must be taught by very positive and active methods, during a period of intensive training together with active participation in operations conducted in the field.

13. The facilities offered by the École nationale des sciences géographiques in Paris, the utilization of which should be chosen for preference for the training of supervisory staff of the highest grades, cover all the specialities and all the levels of training that were enumerated at the beginning of the present memorandum.

14. The instruction there evolves in such a way as to provide students with the theoretical knowledge that is indispensable, supported by a considerable amount of practical work, some of which is carried out in the workshops and laboratories of the Institut géographique national, and some on the practice ground.

15. Besides this, the students participate in a considerable amount of work in the field as members of training groups, as well as in geographical and geological study tours, and in training courses as members of groups of the Institute.

16. Finally, certain cycles of additional theoretical and practical instruction (astronomy, reconnaissance topography, geodesy, photogrammetry, etc.) are regularly organized, and these allow the further training of certain specialists to be completed within a brief space of time.

17. In short, the information given above tends to show that, in spite of the complexity of the difficulties involved in the training of qualified specialists in cartography (by reason of diversity, and of the limited number of staff available for each State), the facilities at present existing or expected to become available in the near future are capable of meeting the most immediate requirements, subject to some adjustments being made.

18. In order to bring this task to a successful conclusion, it would appear desirable to recommend the pooling of available resources, and the fixing, with all the care that is expedient, of the exact spread of personnel required, as well as the corresponding instructional planning.

THE DEVELOPMENT OF SURVEYING AND PHOTOGRAMMETRY AS A UNIVERSITY DISCIPLINE IN EAST AFRICA[1]

By H. S. Williams, M.Sc., B.Sc.(Eng.), ARICS—Head Department of Land Surveying, Royal College, Nairobi

A. Introduction

1. Courses in land surveying were first mounted at the Royal Technical College of East Africa,[2] a recognized College of the Royal Institution of Chartered Surveyors, at the beginning of the 1957/1958 academic session, for the examinations of that institution. This step was taken following a detailed proposal submitted to the Principal of the College by the East African Branch of the RICS in August 1954, requesting the setting up of suitable facilities for the training of land, quantity, valuation and building surveyors.

2. Standards of entry to all first courses were those prescribed by the institution, viz. credits in five subjects at Cambridge Overseas School Certificate level, or equivalent, of which English language and mathematics were mandatory, and physics was desirable.[3] Special provision was made for the direct entry of holders of the General Certificate of Education at Advanced Level, or equivalent, in the subjects—pure mathematics, applied mathematics and physics to the second or intermediate course, by exempting them from the first professional examination. From intake level[4] a minimum of five years full-time study is normally required to reach the final examination.[3]

3. Recommendations by visiting delegations, commissions and working parties on higher education in East Africa[5] led to the acceptance by the East African Governments in 1959, of the concept of a University of East Africa consisting of three constituent Colleges, one situated in each of the three territories. The transformation of the Royal Technical College into a university college was provided by Act No. 4/1960 of the East African High Commission, when this came into force on 25 January 1966.[6] With the reconstitution of the Nairobi College were introduced two important new principles, viz. that education for the professions would be through the medium of appropriate degrees of the new university college (initially in a special relationship with London University) instead of by means of courses leading to the examinations of the professional bodies themselves and, in recent agreement by the territorial governments that the facilities of the University of East Africa should be made available to students of other countries as well. This latter development is most desirable both academically and for the professions, and the governments concerned are to be complimented on their vision in encouraging their university to have a more international flavour.

4. The manner in which the Department of Land Surveying of the Royal College, Nairobi, the second university college of East Africa, can serve other countries, primarily in Africa, but elsewhere as well, is the subject of this paper. However, before proceeding directly to an examination of the structure, content and duration of future proposed courses it is perhaps as well to consider what currently obtains in other countries in relation to survey education, in addition to one or two other preliminaries.

B. Educational and Training Requirements for the Professional Land Surveyor

5. It is universally accepted by land surveyors today that the problem of education is best dealt with by the university, which, after all, specializes in this activity.[7] In this context, we refer to the education of the surveyor who intends making the application and practice of the geodetic sciences his vocation. As part of his subsequent training he will undertake to satisfy any outstanding requirements of a professional body to establish evidence of professional proficiency.

6. The importance of providing the right type of course for the under-graduate in this field cannot be over-emphasized since it is upon the broadly-based foundation of a thorough knowledge of the pure and geodetic sciences (and the applied sciences to some extent) that the organization of future survey activities will depend. Without this background the ability to rapidly understand, assimilate and apply new ideas of the future will be lacking.

7. Training of technician grades at sub-professional level presents problems of a more practical nature, involv-

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[1] The original text of this paper, submitted by Kenya, appeared as document E/CN.14/CART/31.

[2] Created by Act No. 4 of the East African High Commission entitled *The Royal Technical College of East Africa Act*, 1954.

[3] See *The Rules and Syllabus for the Professional Examinations, Land Surveying Section*, August 1953 (as amended).

[4] For delegates unfamiliar with the educational system to which reference has been made the COSC is usually attempted between the ages of 16 to 18 years, approximately 12 years after commencing school. The GCE (a level) examination requires a further two years of study and is of intermediate B.A. or B.Sc. standard of United Kingdom universities. This is the norm, but many African students, making a late start might not reach COSC level until they are some years older.

[5] (*a*) Asquith Report, 1945. Report of the Commission on Higher Education in the Colonies, H.M.S.O. 1945, reprinted 1954.
(*b*) The Ashby Delegation, 1954.
(*c*) The Giffen/Alexander Report, January 1956, *Higher Education in East Africa*, Government Printer, Entebbe.
(*d*) The Lookwood Report, July-August 1958, *Report of the Working Party on Higher Education in East Africa*, Government Printer, Nairobi, 1959.
(*e*) Report of the Quinquennial Advisory Committee, 1960.

[6] The Royal College, Nairobi Act, 1960.

[7] (*a*) *Conference of Commonwealth Survey Officers*, 1955, Colonial Pub. No. 321, H.M.S.O., 1956.
(*b*) Colloquium on Survey Education. Reported in *The Canadian Surveyor*, No. 1, vol. XX, January 1960.
(*c*) University diploma course, *New Zealand Surveyor*, No. 221, February 1962 and editorial of the *New Zealand Surveyor*, No. 222, September 1962.
(*d*) *Proceedings of the First National Conference of South African Surveyors*, July 1961. Obtainable from the Conference Sub-Committee, Box 1089, Durban.

ing the perfection of the elementary field and other techniques, without emphasis on the understanding of fundamental principles. Such instruction is best given on-the-job where training can be oriented in as narrow a way as required. It is not proposed, therefore, to discuss this particular aspect; except to recognize that such men are essential for the day-to-day running of any survey organization and to anticipate that those who find themselves unable to cope with the rigours of academic discipline would gravitate logically towards this avenue of employment.[8] By so doing a source of recruitemnt of technicians with some understanding of principles would become available locally.

8. Various authorities quote from 1 in 3 to 1 in 10 or more, as representative ratios of the professionals to the technicians in survey organizations in different countries of the world. These statistics are useful in obtaining an estimate of the number of fully educated and trained personnel needed in a balanced society.

9. No disagreement, it is hoped, will arise with regard to the above-mentioned related principles of education and proficiency. Nonetheless, it is important when discussing the merits or demerits of any particular education or training programme with the intention of proposing amendments to duration, scope or ultimate qualification, to take cognizance of the rewards that will follow as a natural consequence of the years of hard work and study at the university. The opportunity of proceeding beyond the normal level of academic and professional attainment should be available as an attraction to the keener intellects, for it is upon this individual endeavour that progress depends. Without such initiative in a profession, a sterile future is all that can be expected. The university has a particular responsibility in this regard.

C. Existing patterns of survey education and training

10. In most countries of Europe, the education of the geodetic engineer is provided for by a five-year course at university level. However, these facilities have not been generally available to those countries in Africa which have tended to use the English language as their medium of instruction. For this reason the systems of the English speaking countries are reviewed as they are more relevant, certainly in East Africa.

11. There are six fundamental ways in which a land surveyor may attain full professional status:

(*a*) By obtaining a degree in land surveying, usually followed by a professional pupilage of about one year. Land surveying is used here in its most general sense and includes surveying as such, astronomy, geodesy, photogrammetry, etc.

Such degrees are offered at some universities in Australia, one in Canada (as far as the author is aware) and four in the Republic of South Africa. In the latter case courses are not open to non-white students.

The B.S. degree in the geodetic sciences of Ohio State University may be assumed to fall in this category for the purpose of this classification.

(*b*) (i) By obtaining a first degree in a subject cognate to land surveying such as astronomy (B.Sc. Special of London University), physics, mathematics, engineering and geography (certain degrees only);

(ii) Followed by a subsequent course in surveying, of 12 to 18 months; and

(iii) Completing a two year period of professional experience and any outstanding requirements of the professional body concerned.

The type of course mentioned in (ii) above is often incorrectly referred to as a post-graduate course. This may be chronologically acceptable, nonetheless the term is generally reserved for courses of university standard, at universities, which are open to university graduates only. This leads to the third possibility.

(*c*) A post-graduate diploma or degree following a first degree in a related subject. This would be followed by a professional training period as for (*a*) and (*b*).

Some six or seven universities in the United States offer this alternative, usually following a first degree in civil engineering.

(*d*) By studying the geodetic sciences as a specialized option in a first degree in civil engineering.

This possibility exists in some American and Canadian universities.

These graduates are required to serve a pupilage of one year in Canada. The professional requirements of the land surveyor appear to be somewhat uncertain in the case of the USA.

(*e*) By attending full-time courses at technical colleges directed at the final examinations of the professional body. This would be followed by the normal period of professional pupilage.

As far as the author is aware this procedure is only applicable for the examinations of the Royal Institution of Chartered Surveyors.

(*f*) The indentureship system of earning while learning.

This includes training programmes in government survey departments which may lead to exemption from what may be referred to as a recognized professional qualification.

There is a tendency for this system to be replaced by university courses in most countries, where the latter are available.

12. In examining (*a*) to (*f*) above it will be observed that these range between two extreme limits, i.e. while (*b*) (i) aims at education without proficiency in the geodetic sciences (to achieve part-proficiency an additional course is necessary), (*f*)concentrates on proficiency at the expense of education. Where education in the geodetic sciences is included in the under-graduates' curriculum, education plus part-proficiency may be expected. For this purpose it will be assumed that full-proficiency is established with

[8] Local experience, however, has shown so far that the unsuccessful student prefers to seek scholarship assistance from some overseas Government (and is often successful in his attempt, regardless of a poor academic record) to study in another country.

election to membership of an appropriate professional society.[9]

13. The time taken to qualify by the different methods also justifies scrutiny. Bearing in mind that there is no direct comparison between the educational systems in the schools of Australia, England and South Africa it would not be unreasonable to equate, certainly as to time to graduation, general certificate of education, advanced level plus a three year degree at a United Kingdom University with the South African secondary school certificate (which is a matriculation exemption) and the matriculation of Australia plus four year degrees in the appropriate countries. The relationship of the American and Canadian secondary schools systems to these are not known with any accuracy; however, it would not be far wrong to accept these in the above pattern.

14. By methods (*a*) and (*d*) four years are required to produce an educated and part-proficient recruit to the land surveying profession. The full-time professional courses mentioned under (*e*) take just as long to produce a man at a lower academic level. In fact, the present courses at the Royal College, a relic of the Royal Technical College days, take about a year longer than would an alternative degree course because of the date of the professional examinations being out of phase with the college academic year.

15. Alternative (*b*) was originally introduced as a solution to recruitment shortfalls for the British Colonial Survey Service. Graduates from British universities (preferably with honours) are given a special surveying course at either London University or the School of Military Survey, Newbury, to produce the equivalent of (*a*) and (*d*) above, but takes from 15 to 18 months longer. Method (*c*) would produce roughly the same result but would be somewhat short on the part-proficiency element.

16. As regards (*f*) an average person can expect to take from 10 to 15 years to qualify through this alternative. The discussion has no further interest in this method of training.

17. The important results of this comparison is that methods (*b*), (*c*) and sometimes (*e*) take as much as 15 to 18 months longer than methods (*a*) and (*d*). Further, (*b*) presupposes that an adequate supply of suitable graduates willing to offer themselves for the job-training as land surveyors will be available.

D. The needs of Africa in land surveying education

18. In setting up a survey educational system for the use of African countries it is essential to realize that the transplanting *in toto* of a foreign system, which has worked satisfactorily in its home country is generally not the most satisfactorily and certainly not the most efficient way of producing the desired result.

19. What is required is that course which can achieve the best possible results in the shortest possible time. While no criticism is being levelled at the end product of alternative (*b*) of the previous section, the success of the system depends almost entirely upon the adequate supply of suitable graduates—the most suitable being graduates in physics and mathematics. Those of us in the African universities dealing with survey education would very much like to teach at post-graduate level but for the present idea of a post-graduate diploma would be unrealistic.

20. Secondary education in most of the African countries is still unable to produce adequate scholastic material to ensure an output of a sufficient number of good science graduates. The trickle of these is rapidly absorbed in education, commerce, government, scientific and administrative posts long before they reach surveying. The reason is, quite obviously, that immediate employment without further study represents a far more attractive proposition. Only those with poor results seem to drift towards surveying which finds them no more acceptable than anyone else.

21. For the sake of economy in the university a single system is required which will be able to process suitable scholastic material entering survey studies at different academic levels. Provision must be made for GCE ("O" level) pupils as well as the mature graduate in science. To attract the latter a second degree must be offered, and substantial exemptions granted in those subjects read during the first degree (and perhaps certain other subjects of an ancillary nature which by virtue of the post-graduate's greater maturity may be absorbed as a natural consequence of his further study).

22. The answer, as the author sees it, is a first degree of type (*a*) which would provide education with part-proficiency, yet also attract graduates from faculties of science and engineering and possibly suitable graduates from arts as well.

E. The support of professional societies overseas

23. In the past, close association between professional societies and universities was achieved by:

(*a*) The profession approaching a well-established university to undertake its education problems. Such a situation was rare in the United Kingdom where all professional societies jealously guard their examination rights (or standards), or alternatively;

(*b*) Application was made to the profession for exemption from its examinations, by the university for its degree. In this case the profession concerned generally required that the university courses should "have been conducted for a considerable time" before exemptions were granted. By the application of this formula the quality of the emerging graduate could be assessed before the profession needed to declare its decision.

24. Where the control of professional activities is vested in the profession, i.e. examinating and disciplinary powers, etc. are in the hands of the society's council, the above university/profession relationship would be workable. However, in Africa today there is a great urgency to provide adequate educational courses for the professions at the new universities now. To enable these to get

[9] For the purpose of this discussion no cognizance is taken of the reservations of one country for the professional qualifications of another. The educational principle is all that is being examined.

going the support of United Kingdom societies, for example, would help considerably. New methods of satisfying themselves as to the academic entrance standard, adequacy of curricula, teaching staff, accommodation, equipment and examination system of the university must necessarily be devised by these bodies. Extreme conservatism on the part of councils of professional societies, it must be pointed out, does not influence academic or professional standards. After all, the premise that the academic standards of degree studies at African universities will be lower than the educational minima of the professional bodies in England is not really tenable. Quite the reverse could very well be true.

25. Ultimate control of standards in African universities will be in the hands of the independent Governments. Lack of desire or ability on the part of these Governments to encourage the right staff to the faculties, or to finance the universities properly would certainly lead to a collapse of these institutions as places of learning. The local students are not going to be satisfied with less than their European counterparts and the African politicians must be aware of this and that crash programmes in university education must inevitably lead to a crash. Only the future, however, will reveal the wisdom or lack of foresight of the African leaders in this regard.

26. One of the greatest worries of professional societies prior to agreeing to the sponsorship of courses is undoubtedly the integrity of the university examination system. The societies must be sure that no leakage of information about examination question papers would occur. As long as the staff of the university are members of the profession, reliance on individual integrity can be the only safeguard offered. Professional examinations conducted at overseas centres are wholly under the control of a local examinations officer, a member of the profession concerned, whose personal honesty is the only means the parent society has of saying that its examinations have been properly supervised. Thus, there is no difference in principle between supervision of examinations of a new university and those of the societies at local centres overseas.

27. Visits of inspection teams and the appointment of external examiners should be sufficient to satisfy the societies as regards the items mentioned earlier in this section, as long as the latter have confidence in the university staff.

28. It is hoped that the old established professional societies will continue to perpetuate their influence in Africa by maintaining close links with the new universities. This is most desirable and it is the sincere hope of the author that this will be done. These links are, however, in no way essential as no future African Government would repudiate degrees conferred by its own university but could very well decline to recognize foreign qualifications. It would be a pity, however, if professional links were served in this way, especially before a sound nucleus of local societies was established.

F. Proposals of the Royal College, Nairobi

29. A description of the existing pattern of land surveying courses at the Royal College, Nairobi, was given in the introduction. This falls within the category (*e*) of section C and possesses the disadvantages inherent to the system.

30. Full-time courses in a university college leading to the examinations of an external body are inappropriate; the university must retain control of its own examinations. For this and other reasons the future attitude of the College to these courses will be that they should lead to a degree in surveying and photogrammetry from the University of East Africa. Facilities for the keener intellect to continue studies to the Master's level form part of the proposals, at which level the more gifted student would be encouraged to undertake research studies at institutions overseas. It is hoped that facilities for Ph.D studies in the geodetic sciences would ultimately be available locally as well.

31. The proposed degree would normally be of three years duration from the general certificate of education, advanced level standard[10] in anticipation of secondary schools increasing their output of scholastic material at this level.

32. The following candidates would be eligible for admission to the degree:

(*a*) Graduates in science, having taken two of the subjects mathematics, physics and geography as major subjects, or

(*b*) Graduates in arts, having taken the subjects mathematics and geography as major subjects, or

(*c*) Graduates in civil engineering, or

(*d*) Students who have passed the separate subjects pure mathematics, applied mathematics and physics, at one or separate sittings in the higher school certificate, or have obtained passes in the same subjects at advanced level in the general certificate of education examination, or equivalent;[10] or

(*e*) Students who have passed pure and applied mathematics (combined subjects), physics and one other subject, acceptable to the Senate of the University, in the general certificate of education, advanced level or equivalent,[10] or

(*f*) Students who have passed the first professional examination of the Royal Institution of Chartered Surveyors, or

(*g*) Students who have passed other appropriate examinations acceptable to the university.[11]

33. Candidates who offer option (*a*) would be required to complete the qualifying of the second and third years of study (no restriction as to time would be imposed). Exemptions would be granted from subjects included in the B.Sc. degree.

34. For those who offer option (*b*) the physics (special course) of the first year would have to be completed as well.

35. All B.Sc., B.A. and B.Sc. (Eng.) graduates would be permitted to complete outstanding first and second year courses in appropriate subjects, as combined courses, e.g. photogrammetry I and II would be combined as a special

[10] Intermediate B.Sc. standard of London University.

[11] A pass in English language at GCE (0 level), or equivalent is mandatory for these sections.

second year course (see below). No ancillary courses would be imposed.

36. Candidates offering options (*d*) to (*g*) would be required to satisfy the requirements of the first, second and third years of study for the B.Sc. Eng. degree, in surveying and photogrammetry, as described below:[12]

(*a*) The qualifying courses for the first year of study would be:

Mathematics I;
Physics (Special course);
Photogrammetry I;
Law and land registration I;
Cartography I;
Surveying I.

In addition the student would also attend satisfactorily courses in principles of engineering and English.

A candidate would not obtain credit in any qualifying course unless he completed four of the following courses in the same academic year:

Mathematics I;
Photogrammetry I;
Land registration I;
Cartography I;
Surveying I.

Permission to proceed to the second year of study would not be given by the Senate unless all qualifying courses, prescribed for the first year of study, had been completed, and satisfactory results obtained in principles of engineering and English.

(*b*) The following subjects would be prescribed for the second year of study:

Mathematics II;
Surveying II;
Astronomy I;
Land registration II;
Photogrammetry II;
Cartography II.

In addition the candidate would attend satisfactorily a course in town planning.

[12] Draft detailed syllabuses and practical course work requirements may be obtained from the author.

The candidate would not obtain credit for any qualifying course unless he had completed at least four such courses in the same academic year.

Admission to the third year of study could only be obtained by completion of all qualifying courses in the first and second years of study, and satisfactory results obtained in the additional subjects specified, except by special permission of the University Senate.

(*c*) The following subjects would be prescribed for the third year of study:

Mathematics III;
Geodesy and geophysics;
Photogrammetry III;
Astronomy II.

No candidate would obtain credit in respect of any qualifying course for the third year of study unless he had completed three such courses in the same academic year.

37. A system of supplementary examination could be applied immediately following the College long recess to enable those students with incomplete credits to satisfy the entry requirements for the next year of study. By this means, the disadvantage of the professional courses of having to wait a whole year to re-write one subject would be removed. A smoothing and speeding up of the undergraduate's way to his final hurdle would be achieved.

38. Provision for graduation with honours would also be provided for those who maintain a consistently high performance throughout their degree studies and who present a thesis of a suitably high standard acceptable to the Senate of the University.

39. The proposed degree course described above has been designed to replace the present full-time professional course in land surveying in East Africa.

G. Conclusion

40. Ways of improving the approach to education in the geodetic sciences in Africa for indigenous countries, have been outlined in this paper, particularly with regard to a more efficient handling of the duration of the period of study involved.

41. In conclusion, it should be said that the Royal College, Nairobi is most willing to assist with this type of education and has facilities for this purpose, which are being steadily improved.

EDUCATION AND TRAINING FOR STAFFING SURVEYING AND MAPPING OPERATIONS

By Brother B. Austin Barry, F.S.C., Associate Professor of Civil Engineering, Manhattan College, New York, New York

[*The original text of this paper, contributed by the United States of America, appeared as document E/CN.14/CART/88. This paper was originally prepared for the United Nations Conference on the Application of Science and Technology for the Benefit of Less Developed Areas, Geneva, 1963. It has been published in volume II,* Natural Resources, Minerals and Mining, Mapping and Geodetic Control, *by the Agency for International Development. This publication is on sale at the Superintendent of Documents, Washington, D.C.*]

AGENDA ITEM 9

Technical assistance

(No papers were presented under agenda item 9)

AGENDA ITEM 10

Organization of international co-operation

INTERNATIONAL CO-OPERATION IN COMPILING MAPS COVERING SEVERAL STATES[1]

Institut Géographique National, Paris

International co-operation in map publishing, whatever the scale, can only be achieved by *bilateral conventions* between the institutions producing the maps.

In the case of maps covering several States, two questions arise: that of cutting and that of co-production.

It should be borne in mind that the *sheet lines* of the modern series are derived from theoretical *sheet lines* of the *International Map of the World on the Millionth Scale* (IMW) (in latitude zones of 4° and in longitude belts of 6°).

At large scales, medium scales and small scales down to 1:500,000, this arrangement of the sheet lines undergoes modifications in longitude at frontiers so that the *territory of a State* may be completely covered by the minimum of sheets.

At the scale of 1:1,000, for which Lambert's projection, by zones of 4° latitude, is universally adopted, the theoretical cutting undergoes changes in longitude, and more rarely in latitude, in such a way that a *continent* may be covered by the minimum of sheets, with overlaps, where necessary, so as to achieve a better adjustment to the political division. The same applies to the scale of 1:2,000,000.

In co-production, whatever the scale, responsibilities are divided between the two producing States.

The French Institut géographique national, bearing in mind the difficulties and failures in the past, is proposing a *co-production* arrangement on an effort to achieve maximum economy, flexibility and efficacy:

"Each producing State must have its own edition at its disposal, and for that purpose every State shall prepare the model,[2] key line and lettering concerning its own territory exclusively, and send it to its partner with the base documentation used.

"Each state shall prepare and edit the sheet according to *its own standards.*

"The trial proofs will be exchanged, each state examining only its territory.

"Subsequently, when further editions are published, the revised models will be exchanged, each state dealing only with its own territory."

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[1] The original text of this paper, submitted by France under the title "Note sur la coopération internationale pour l'établissement des cartes à cheval sur plusieurs états", appeared in French as document E/CN.14/CART/17.

[2] For the *base maps*, the model consists of the monochrome print of the key plates of the national edition.

For maps compiled from secondary sources the name "model" is given to the assembly (on a projection sheet at the scale of the edition) made by gluing on to bromide paper the proofs obtained by photographic reduction of the over-all compilations.

In a general process, the model makes possible the preparation of provisional base maps which are used for the preparation of the basic "key" plates.

INTERNATIONAL CO-OPERATION ON CARTOGRAPHY[1]

By the secretariat

1. At its twenty-first session the Economic and Social Council, in concluding its examination of the report of the United Nations Regional Cartographic Conference for Asia and the Far East, adopted a resolution on the subject of international co-operation in cartography [Resolution 600 (XXI)]. In this Resolution the Council, recognizing "the importance of accurate and reliable cartographic information, more especially in connexion with economic development projects", recommended, *inter alia*, "that those regional economic commissions which think it desirable consider the question of establishing cartographic committees for the purpose of periodic consultation among their members".

2. The Economic Commission for Africa, in view of the forthcoming Regional Cartographic Conference for Africa, has not yet considered the question.

[1] The original text of this paper appeared as document E/CN.14/CART/30.

INTERNATIONAL CO-OPERATION IN CARTOGRAPHY—THE INTER-AFRICAN CCTA/CSA COMMITTEE FOR THE COMPILATION OF MAPS[1]

By the Commission for Technical Co-operation in Africa

As long ago as 1949, the Johannesburg African Scientific Conference turned its attention to examining to what extent it might be possible to harmonize or standardize certain cartographic data (ellipsoid, the system of projection to be adopted, the definition of sheet lines, scales, conventional signs, and transcription of toponomy).

2. At its request, an inventory of the types of maps existing in Africa was compiled,[2] and then revised, added to and amended,[3] following a meeting of specialists in cartography and topographical surveys held at Bukavu in September 1953.

3. This important meeting, which brought together the vast majority of the representatives of those nations that were, at the time, responsible for cartographic policy in Africa south of the Sahara,[4] laid down the course of action to be followed in order to satisfy the general wish expressed in 1949 by the Conference already mentioned.

4. In particular, the following recommendations were made:

That the aim should be to use, for new maps, the modified Clarke ellipsoid of 1880, which had already been used for the greater part of Africa;

Adoption of the UTM projection (Universal Transverse Mercator) in covering a lune width of 6 degrees for medium-scale terrestrial maps;

Adoption of the sheet-line system of the *International Map of the World*, or else of its projection, for scales of 1:1,000,000, 1:500,000, and 1:250,000; in the case of larger scales, retention of the custom of utilizing, as the limits of map-sheets, meridians and parallels of latitude in round figures corresponding with degrees or fraction of degrees;

Generalization of the use of metric scales, such as 1:100,000 and 1:50,000, rather than scales expressed in inches to the mile or in miles to the inch; retention of freedom of choice between scales of 1:200,000 or 1:250,000, of 1:125,000 or 1:100,000, and of 1:25,000 or 1:20,000;

The undertaking of a review of conventional signs used on their maps by the different countries concerned, in order to try, as far as possible, to achieve uniformity. This review was entrusted to the representative of France;

Respect to be observed in questions of toponymy, on general maps published by a given country and therefore in the language of that country, for the spelling used by the country represented. The issuing country is only entitled to show in brackets the translation of a name into its own language;

As regards units if measurement, freedom of choice as between metres or kilometres and the corresponding British units of measurement; nevertheless, adoption of the UTM projection should lead to uniformity of the measuring grid, which should be shown in kilometres. Besides this, in maps on scales of less than or equal to 1:200,000, and in order to facilitate international use, it was recommended that a double scale of distances should be used, showing both miles and kilometres. For the same reason, heights adopted as the limits of layer tints, should be accompanied by a conversion table in metres.

5. Although it took place as much as ten years ago, it would be impossible to exaggerate the importance of this Bukavu meeting, where eminent cartographic specialists, convened on the initiative of a non-political Scientific Council, succeeded in framing, by common consent, a sort of "Cartographic Charter" for Africa south of the Sahara, which laid down the aims to be attained, so as to

[1] The original text of this paper appeared as document E/CN.14/CART/36.

[2] CSA publication No. 4, April 1953.

[3] CCTA/CSA publications Nos. 15 and 17, 1955.

[4] That is to say the nations whose territories straddle or are situated south of latitude 20° north.

harmonize cartographic standards in such a way as to progress towards a system of cartography, as uniform and continuous as possible, for the part of the African continent coming under their jurisdiction, thus facilitating international use of the documents produced.

6. The Bukavu meeting did not, however, confine itself to this question.

7. On the economic side, it drew the attention of member Governments to the urgent question of putting at the disposal of the topographical or cartographic services adequate resources to enable them to compile within the desired space of time—that is to say, in accordance with systematic pre-arranged programming—those maps, the lack of which threatened to delay the implementation of numerous development plans or projects.

8. On the scientific side, it put forward suggestions regarding the order of priority to be observed in the triangulation work that was to be undertaken, and recommended the extension[5] and connexion between States of the already existing works of precise levelling, so as to enable a general adjustment of networks to be made for the whole of the African continent. It also turned its attention to the development of physical oceanographical work along the coasts of those territories coming under its jurisdiction.

9. Finally, as regards topical maps, specific provisions were worked out at Bukavu regarding the definition of standards governing their compilation (scale, projection and sheet-line system) and the utilization by compilers and publishers of these topical maps, and of base maps for topographical or general maps issued by the producing services, which should undertake to provide them at a reasonable price.

10. Lastly, the Bukavu meeting recommended the setting up of a permanent committee of cartographic experts to maintain a permanent liaison in respect of all cartographic questions, both by correspondence and by the exchange of reports and programmes, as well as by holding periodical meetings.

11. From this resolution there emerged the Inter-African Consulatative Committee on Maps and Topographic Services which held its first meeting in London in August 1955, and met again in Capetown in November 1957, having changed its title to Inter-African Committee for the Compilation of Maps and Topographical Surveys, and drawn up its status.[6]

12. Two further meetings have been held since then, one at Lisbon in April 1960, and the other at Salisbury in June 1962, the latter having been preceded by a discussion on the developing countries' requirements for maps and topographical surveys.

13. During these various meetings, the following matters were reviewed, discussed or put into effect.

14. As regards topical cartography, the preparation of standard base maps on scales of 1:5,000,000 1:10,000,000, 1:15,000,000, 1:30,000,000, designed for various topical atlases (climatological, botanical or the distribution of vectors of diseases), or for various topical maps (pedological, population density, distribution of Quelea birds, etc.), and resulting from various joint projects decided upon by CCTA/CSA, was brought to a successful conclusion by the South African Government.[7] The compilation of a certain number of these specialized maps by the specialists concerned has, furthermore, either been completed or is nearing completion.

15. Mention should also be made of a magnetic map submitted to the Capetown meeting, the edition of which have to be periodically kept up to date in step with the progress achieved in work on magnetism.

16. In topographical or general non-topical cartography, a number of new measures were likewise introduced:

A project to standardize the "main" conventional signs, conceived in the spirit of Bukavu, was proposed by France and accepted at the Lisbon meeting (1960) for all new types of maps;

With regard to maps on a scale of 1:1,000,000, the Federation of Rhodesia and Nyasaland presented at Capetown (1957) a draft map, compiled on a 1:1,000,000 scale, designed to meet both requirements of the international ICAO map and other requirements as well, in particular those of the *International Map of the World* (IMW). Similar proposals were studied at the United Nations Regional Conference for the Far East in Tokyo (1958) where it gave rise to long debates. It was taken up again by the CCTA Committee at Lisbon (1960), which decided on the adoption of the ICAO Lambert Projection for all new maps on a 1:1,000,000 scale for the countries south of the Sahara. The matter was settled by the United Nations Technical Conference on the *International Map of the World on the Millionth Scale* that met in Bonn in 1962. From that, there should result a certain alleviation of the obligations to be assumed by States in international cartography on this scale. With regard to this same map, suggestions for modifications to the uniform limits of map-sheets laid down in 1913, in such a way as to simplify and alleviate the task of each member State, resulting from its obligations in this connexion were introduced at Salisbury, in some cases with success.

17. Finally, with regard to direct co-operation between member States, emphasis was laid in the course of the various meetings on the necessity for exchanges, between member States, of information on geodesy, topography, magnetism and precision levelling, so as to render the different kinds of work which the various member States were carrying out, each on its own account, in each of the disciplines coming under the jurisdiction of the Committee, more coherent, easier and of more general value.

18. The political evolution of recent years has contributed to altering the number of member States on the Committee, which has tended to increase. This evolution has not, on that account, paralyzed its activity; but it renders still more necessary now than formerly, in parti-

[5] In particular, with a view to the development of the gravimetric network, which had already reached an advanced stage in French and Belgian territories and in South Africa, the extension of which was, however, limited in other areas by the absence of precision levelling.

[6] CCTA/CSA document (57)-5.

[7] The characteristics of these base maps are explicitly set forth in a special paper submitted under item 10 of the agenda (international maps).

cular for countries south of the Sahara that have recently achieved independence, exchanges of information and documentation, especially so far as the techniques used in cartography are concerned. The presence on the Committee, for several years to come, of representatives of the majority of non-African countries which founded it, as a guarantee of its efficacity in the perfecting of cartographic techniques, as it thus constitutes a committee of specialists in these subjects. Moreover, thanks to their support as regards active co-operation both in the financing of pro-programmes and the training of African technicians, it is permissible to take an optimistic view of the progress of cartographic equipment of States south of the Sahara, which constitutes an essential prerequisite for carrying out the majority of development plans affecting them.

19. For all these reasons, the Inter-African Committee for the Compilation of Maps and Topographical Surveys constitutes a regional organization having at its disposal technical potentialities of high quality, and well-equipped to co-operate with the United Nations Economic Commission for Africa by methods that still remain to be worked out.

INTERNATIONAL CO-OPERATION IN SURVEYING AND MAPPING IN THE AMERICAS

By Colonel John E. Unverferth, Corps of Engineers, U.S. Army,
Director, Inter American Geodetic Survey, Fort Clayton, Canal Zone

[*The original text of this paper, contributed by the United States of America, appeared as document E/CN.14/CART/67. This paper was originally prepared for the United Nations Conference on the Application of Science and Technology for the Benefit of Less Developed Areas, Geneva, 1963. It has been published in volume II,* Natural Resources, Minerals and Mining, Mapping and Geodetic Control, *by the Agency for International Development. This publication is on sale at the Superintendent of Documents, Washington, D.C.*]

AGENDA ITEM 11

Regional projects

INTERNATIONAL CO-OPERATION ON CARTOGRAPHY—REGIONAL PROJECTS[1]

By the secretariat

1. At its fifth session held in Leopoldville from 18 February to 2 March 1963, the Economic Commission for Africa, in concluding the consideration of the report of the Working Party of the Whole of the Standing Committee on Industry and Natural Resources,[2] decided to include in its continued projects and activities of high priority a task defined in the following terms: "Preparation, in co-ordination with UNESCO and other specialized agencies concerned, for the setting up of a regional centre for the interpretation of aerial surveys, and another for training in photogrammetry and airborne geophysical prospecting".[3]

2. In view of the need expressed by many developing countries for training competent technical personnel in various branches of modern surveying and mapping to strengthen and develop the capability of their respective national cartographic services, and in view of the wide application of the above-mentioned cartographic techniques, not only in the study and exploitation of natural resources but also in other economic and social projects, such as urban and rural development, land resettlement, road and railroad construction, air and nautical navigation improvement, agricultural development etc., the Conference may wish to consider the proposed regional projects in the light of information brought forward by participants on existing facilities in the continent and on immediate and long-range requirements of such training.

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[1] The original text of this paper appeared as document E/CN.14/CART/38.

[2] E/CN.14/192.

[3] Annual report of the Economic Commission for Africa to the Economic and Social Council, covering the period 4 March 1962 to 2 March 1963 inclusive: project 23-01, paragraph (i).

AGENDA ITEM 12

International maps

INFORMATION PAPER ON THE "INTERNATIONAL MAP OF THE WORLD ON THE MILLIONTH SCALE"

By the secretariat

[*The original text of this paper appeared as document E/CN.14/CART/50. The paper also appears in the* Report of the United Nations Technical Conference on the International Map of the World on the Millionth Scale, *Bonn, 1962—United Nations publications, sales Nos. 63.1.20 and 64.1.4.*]

NOTES CONCERNING AERONAUTICAL CHARTS[1]

By the International Civil Aviation Organization

1. The International Civil Aviation Organization (ICAO) has supported the United Nations Regional Cartographic Programme since its inception and has been represented as far as possible at the Regional Cartographic Conference. ICAO desires to participate in the encouragement given by such conferences to surveying and mapping for it is of the opinion that in general the rate of economic progress depends to some extent on the existence of suitable maps and charts, and that, in particular, accurate charts must be available for all phases of aircraft operations.

2. One of the main functions of ICAO is to develop international standards and recommended practices in various fields of aviation, those relating to aeronautical maps and charts being contained in annex 4 to the Convention of International Civil Aviation. Copies of annex 4 can be supplied to the Conference.

3. Under the Chicago Convention, contracting States are obliged to provide civil aviation with several specified types of charts and to prepare these and other optional types in conformity with the specifications included in annex 4. The obligatory types of charts are the Aerodrome Obstruction Charts—Type A (operating limitations), instrument approach charts, landing charts and the World Aeronautical Chart ICAO 1:1,000,000. The latter is a world-wide series, the responsibility for publication being shared by a large number of States under a programme monitored by the ICAO secretariat. Each State, also, is under an obligation to make topographic and aeronautical information available to other States that publish charts covering all or part of the territory of the State concerned. The necessary aeronautical information can be communicated to other States by means of the normal aeronautical information documents which a State must publish under annex 15 to the International Civil Aviation Convention. Copies of annex 15 are available for examination.

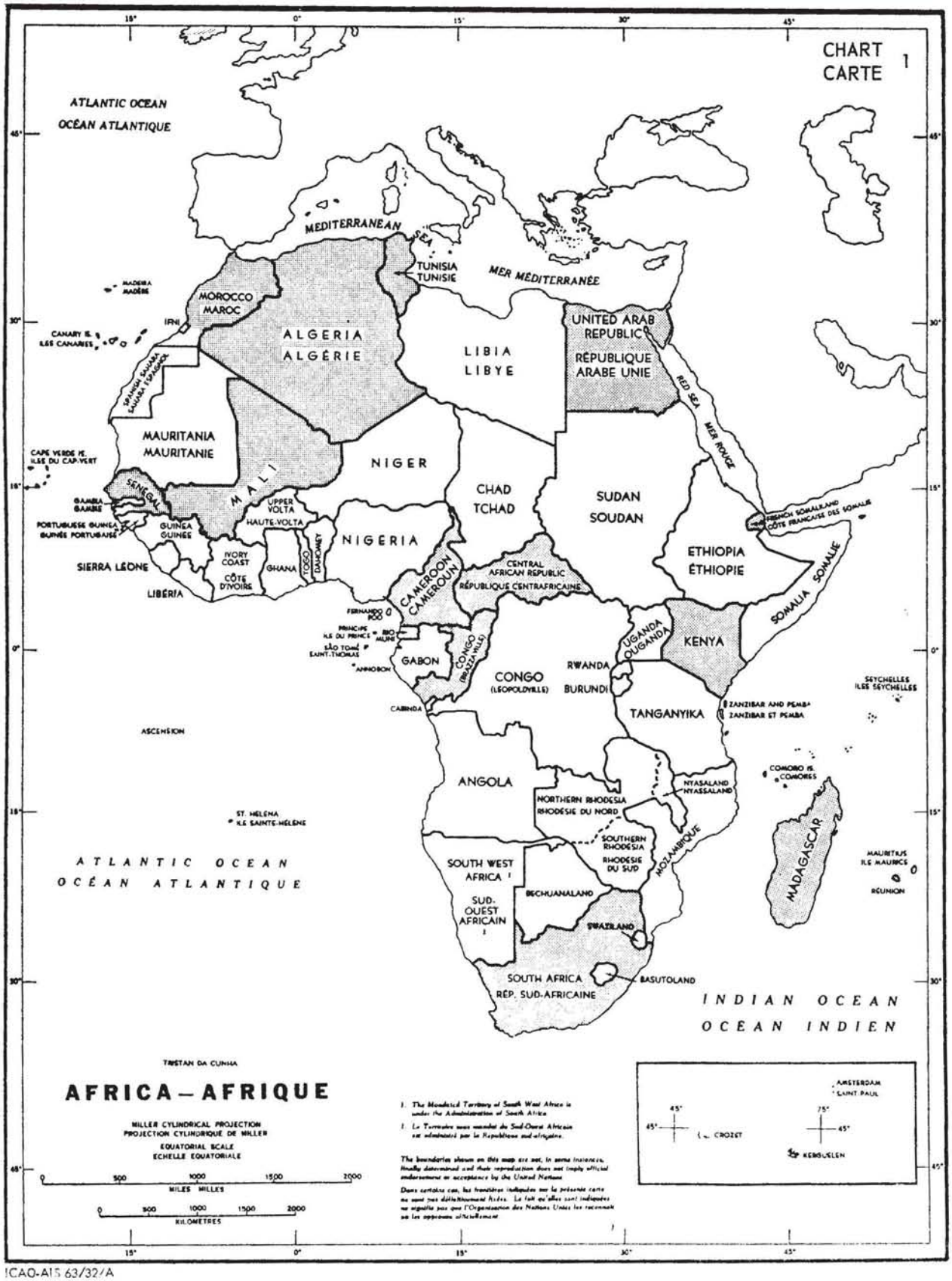
4. Small scale charts, i.e. planning charts, plotting charts or radio navigation charts covering all or parts of Africa are published by France, Italy, the Republic of South Africa, the United Kingdom and the United States of America. It would appear that charts of this type should continue to be produced by a few States in the interest of efficiency and economy as regards both producer and user. The obligation to provide basic aeronautical information, mentioned earlier, would particularly apply to these charts.

5. Although considerable progress has been made in the provision of suitable aeronautical charts for the African continent, much still remains to be done and a programme needs to be formulated to ensure that the required charts are produced and are maintained up to date; many are now out of date. The attached index charts indicate the countries or territories for which the obligatory type of charts are being produced; however, these index charts do not give a qualitative assessment. For example, although an increasing number of States produce aerodrome obstruction charts, only a few of the many international aerodromes have been covered. ICAO publishes an Aeronautical Chart Catalogue (Doc 7101-MAP/565), which provides information on all aeronautical charts available to civil aviation; copies of this catalogue are available for examination.

6. In view of the work accomplished by ICAO in aeronautical charting, it is considered that it is hardly in the interest of the Conference to discuss chart specifications or requirements but rather that it should make every effort to meet existing requirements. The Regional Offices of ICAO (at Cairo and Dakar) are ready to give all possible advice to States respecting their aeronautical charting programmes.

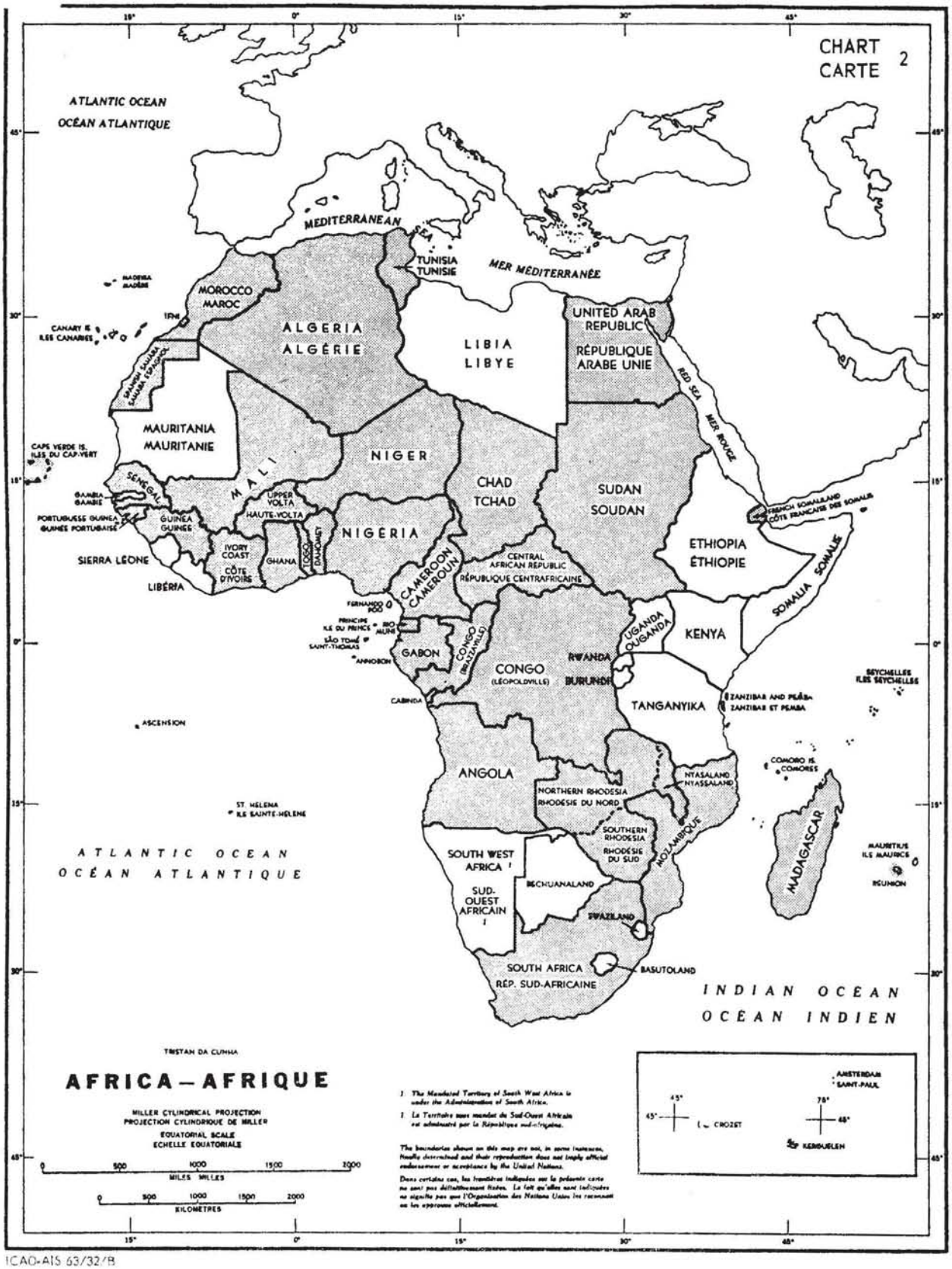
[1] The original text of this paper appeared as document E/CN.14/CART/52.

STATES PROVIDING AERODROME OBSTRUCTION CHARTS - ICAO, TYPE A (OPERATING LIMITATIONS)

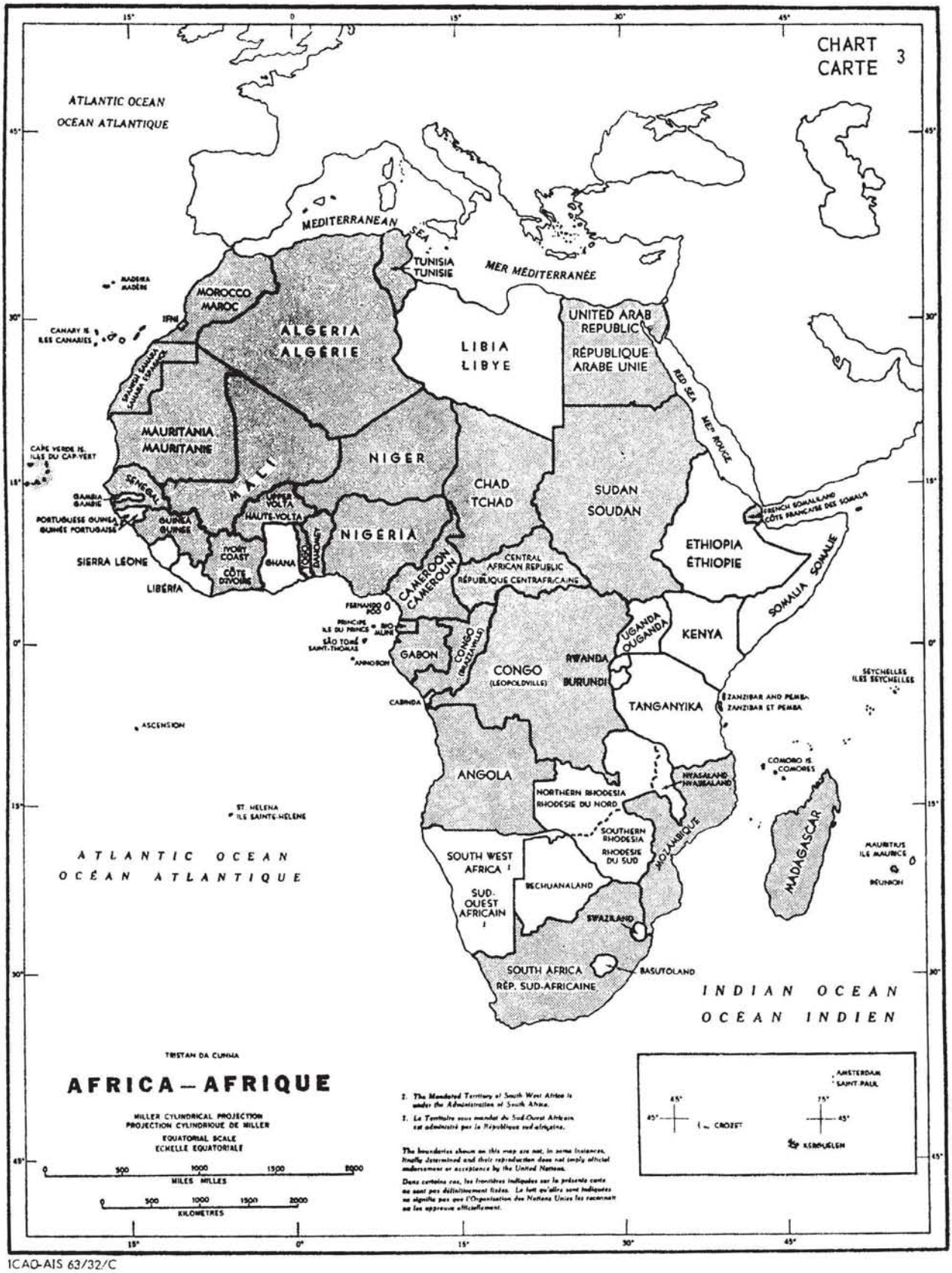


ICAO-AIS 63/32/A

ICAO : States providing aerodromes obstruction charts

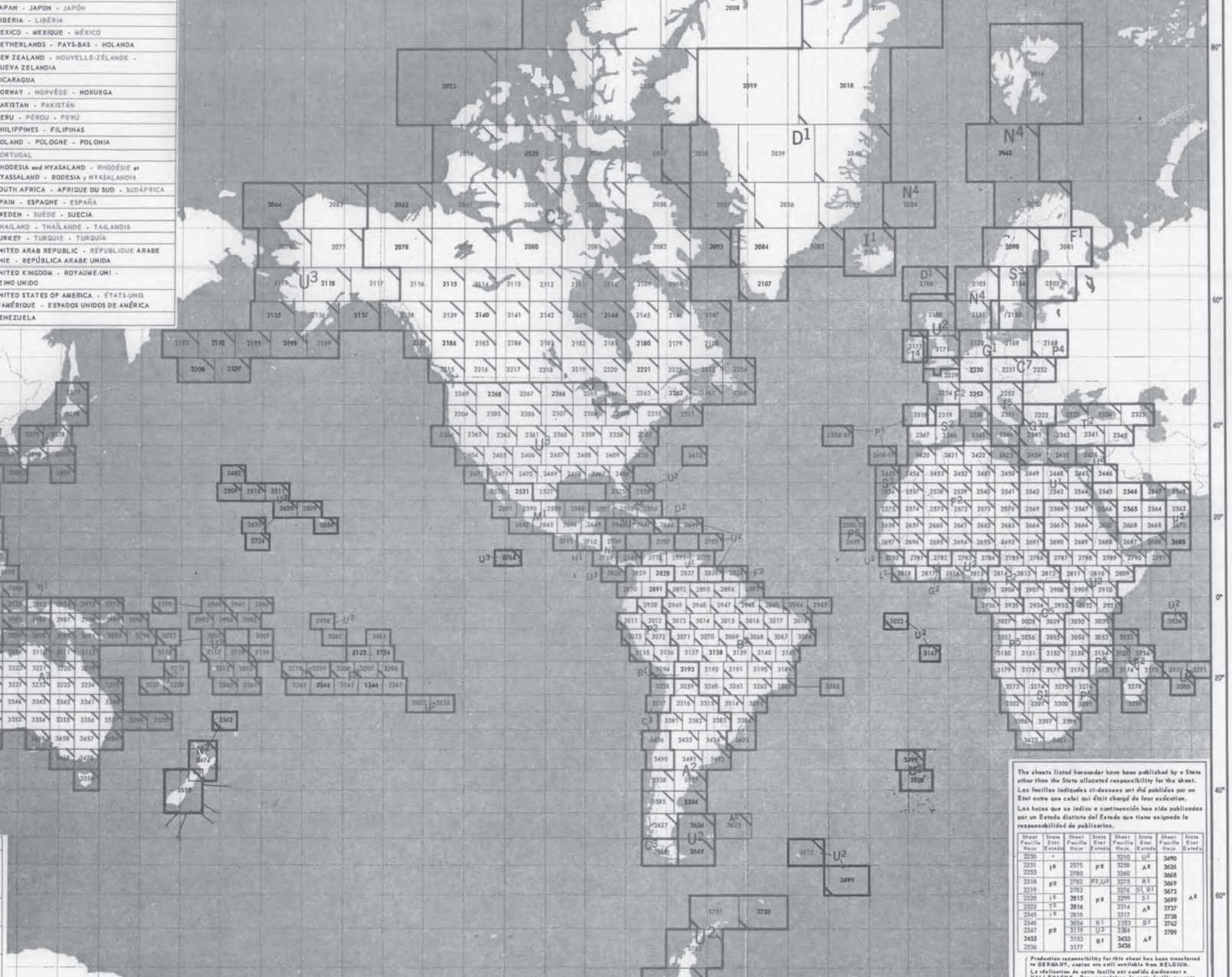


ICAO : States providing instrument approach charts



ICAO-AIS 63/32/C

ICAO : States providing landing charts



The sheets listed hereunder have been published by a State other than the State allocated responsibility for the sheet.

Les feuilles indiquées ci-dessous ont été publiées par un Etat autre que celui qui était chargé de leur exécution.

Las hojas que se indica a continuación han sido publicadas por un Estado distinto del Estado que tiene asignada la responsabilidad de publicarlas.

Sheet Feuille Hoja	State Etat Estado	Sheet Feuille Hoja	State Etat Estado	Sheet Feuille Hoja	State Etat Estado	Sheet Feuille Hoja	State Etat Estado
2230	*			3210	U^2	3490	A^2
2231	I^5	2575	F^2	3258	A^2	3626	
2253		2780		3260		3668	
2318	F^2	2782	$F2, U^2$	3275	R^1	3669	
2319		2783		3276	S^1, R^1	3672	
2320	I^5	2815	F^2	3299	S^1	3699	
2322	T^2	2816		3314	A^2	3737	
2345	I^5	2818		3317		3738	
2346		3054	R^1	3383	B^1	3762	
2347	F^2	3119	U^2	3384		3789	
2455		3152	R^1	3433	A^2		
2536		3177		3438			

* Production responsibility for this sheet has been transferred to GERMANY, copies are still available from BELGIUM.

La réalisation de cette feuille est confiée dorénavant à [illegible]

Rectified and enlarged photograph

AGENDA ITEM 13

Technical questions on basic mapping

General

BENEFITS ACCRUING FROM THE EXCHANGE OF CARTOGRAPHIC SOURCE MATERIALS AND TECHNICAL INFORMATION[1]

By Philip Rahall, Assistant Director of Operations, Aeronautical Chart and Information Center, United States Air Force, St. Louis, Missouri

The business of making maps is more complex today than ever before. The technology of the 1960's changes almost daily and the impact of new equipment, techniques, and methods of operation are felt at every turn. The successful cartographer must be aware of the research and development under way in industry and the sciences. He must evaluate each new item in terms of its contribution to his ultimate goals and arrange to make use of those he considers most valuable. This is no simple task and the modern cartographer must make use of every means at his disposal to meet the challenge. With these facts in mind, I want to talk of some of the major problems the map maker faces and discuss the advantages of one method that will aid in the solution.

Regardless of purpose, today's cartographic programme must make use of highly specialized techniques and processes. As I said a moment ago, this requires keeping up to date with related research and development projects. Then there are the problems of finding and using the best source materials; of keeping well informed regarding other cartographic activities in the world; and of scheduling production to make use of new materials in preparation in other agencies.

I think you all would agree that it would be virtually impossible for any mapping agency to secure the best solutions to all problems of cartographic production solely through its own resources. It is this realization which has prompted many agencies to initiate co-operative arrangements—the practice of exchanging cartographic source materials and technical information.

An arrangement or understanding between two agencies to exchange cartographic information may be limited to a simple exchange of printed maps or it may be expanded to include the co-operative preparation of joint-use products. A working arrangement can be used to avoid costly duplication of effort in the participating organizations and it most certainly will contribute to the production of more complete and accurate maps and charts by both groups.

I propose to examine some of the mutual benefits of national participation in cartographic exchange programmes. For example, let us look at what happens when a national map series approaches an international boundary. The information shown on the boundary line sheet can end abruptly in the middle of the sheet at the boundary—or it can progress smoothly to the edge of the sheet. Naturally if you are to complete the sheet, you will need information from a neighbouring mapping agency. In the process of obtaining the data, production schedules are likely to be discussed. Perhaps the material you need is not prepared or the neighbour wants information from you to complete sheets at another point along the boundary.

Ideally, such an interchange would lead to an agreement that both of you will concentrate your production along a given segment of the boundary in question and you will exchange compilation drawings. Then you would both be in the enviable position of being able to publish complete and accurate maps. In the event that both of you use the same sheet layout, you might even produce a map and furnish your neighbour with reproduction copy, and vice versa, for printing. This certainly would have the effect of reducing production time and costs for both countries involved.

Unfortunately the ideal co-operation I have just outlined is seldom realized. However, in most instances it is quite practical to exchange information regarding production plans. Then both of you would have a reasonable basis for establishing practical dates for initiating production of the boundary line sheets.

When parties to an exchange agreement share a common area of interest, every effort should be made to include specifications, quality standards, and indexes of geodetic and aerial photographic surveys in the agreement. Such information is very helpful to each agency in the development of individual production schedules. Then too, when a compiler of one agency is using a map of another country as source material for matching details along the national boundaries he may need to refer to the specifications and quality standards to resolve differences in alignment or match-point features. Variances in road classification, selection of populated places, placement of a shoreline, or the delineation of a swamp area can

[1] The original text of this paper, contributed by the United States of America, appeared as document E/CN.14/CART/62.

often be explained by the extent of generalization permitted in the national mapping standards. Indeed, there are many instances where knowledge of specifications is useful to the technician working with foreign compiled source material.

In this same connection, the national geodetic networks of one part may be computed on a different reference ellipsoid than the other party used. Difficulties will be encountered in matching detail where maps based on the two networks meet at the boundary. Furthermore, the plans of one nation for expanding a triangulation network could easily be affected by the plans of a neighbouring nation. Mutual exchange of triangulation indexes along with plans for extending networks should always be an objective of exchange agreements.

Finally, an exchange agreement could be used as a device for securing the edit and correction of compilation copy when neighbouring territory is included on a national map. Verification of the spelling of place names and the delineation of roads and city outlines are not difficult or expensive services especially when they are measured against the good will and co-operation which is generated.

Most agencies are pleased to exchange their printed maps and map catalogues. Such reciprocity is a normal courtesy extended among national cartographic agencies. Eventually, the maps go to a national map reference file for public use. However, they are studied very carefully first for indications of new specifications and improved cartographic techniques. The maps indicate the level of professionalism achieved by the producers and any new techniques which can be identified are evaluated by receiving agencies for use in their own production. The spirit of friendly competition generated in this sort of exchange is very desirable because it keeps cartographers alert to developments in their profession and furnishes an incentive for improved capabilities.

As I pointed out earlier, the task of remaining abreast of technological development is tremendous. Here again, exchange agreements can provide channels for technical information regarding the experimentation and improvements inaugurated by other agencies. Cartographers are drawing ideas, devices, materials, and techniques from a variety of technologies and often the seminars and conventions held by such professional organizations as the International Society of Photogrammetry, the International Union of Geodesy and Geophysics, the International Cartographic Association furnish an opportunity for the exchange of technical information. The specialized equipment which manufacturers usually display at conventions is also a means of keeping current on research and development in that field.

The scientific societies I just mentioned direct their efforts toward improving the professional cartographer. The exchange of information through society sponsored seminars and conventions promotes the idea of individual achievement and personal contact. They serve as clearing houses of information which can be drawn upon by participating members—working level and supervisory. Technical personnel are always seeking new ideas and they enjoy contacts with their counterparts in other agencies and the meetings of local chapters of the societies serve as a forum for the exchange of ideas and accomplishments.

The major cartographic agencies of the world have well established programmes for the production of technical reports regarding processes or techniques which they have developed. These are available on request and any organization planning an effective mapping plant should obtain as many as possible. Plant managers, planning staffs, compilers, drafting departments, and printers will all benefit in one way or another from the exchange of this type of information.

And quality control is one of the newest and most promising techniques which might be included in an exchange arrangement. The colour of inks—which has long been measured by the eye of the pressman—can now be controlled accurately by electronic devices. The line width on a printed chart is controlled by the size of the cutting head on the scribing tool and the length of exposure during the plate making stage. Here again, the skilled eye of the technician once determined the exposure length, but electronics has taken over. All sorts of information concerning the equipment and machinery for these purposes are available for the asking through exchange with other agencies and from manufacturers.

Are you having difficulties in obtaining paper of a suitable quality? Does humidity cause your drawings to go out of registration? Perhaps your photo processing is not yielding sharp negatives. Very likely other cartographic agencies have experienced identical problems and would be pleased to tell you how they solved them.

Any discussion of benefits to be gained through exchanging information would not be complete without discussing the international agencies working toward the standardization of cartographic products—such as the International Civil Aviation Organization (ICAO) and the International Hydrographic Bureau. Very often these groups will act as intermediaries for establishing cooperative mapping or charting production agreements. Through their status as internationally accepted groups for standardization, they can delegate areas of mapping responsibility. In instances where a state cannot meet its responsibility they will be assisted in the designation of an alternate production office. Further, through specification standardization programmes, these organizations can call international conferences. The representatives of cartographic organizations who are present at the conferences act as agents of their governments and the agreements made become formal commitments.

I said when I started that I wanted to discuss the benefits of exchanging cartographic information. I have by no means exhausted the subject and, as you develop these arrangements, you will undoubtedly realize many other advantages. It seems to me that the real value of the arrangement lies in the fact that both parties gain. It is a mutual process which can only develop good will and further co-operative effort. It is an important phase of the development of the professional stature of an organization because it provides a way for you to keep up with the developments in your business. It furnishes the opportunity to display your accomplishments. It promotes efficiency through the increased competency of your technical staff. When production schedules can be included, it will help you to achieve more effective schedules and

better production management. And it surely leads to good international relationships.

The negotiation of an exchange arrangement—agreement if you like—is very simple when it is approached informally on an agency to agency basis. A simple arrangement is preferable where large quantities of materials are involved.

I firmly believe that the exchange of cartographic materials and technical information among the national mapping agencies of the world represents the most comprehensive method of solving the complicated problems of modern cartography. It is a practice which should be exploited to the fullest extent possible.

PRACTICAL CONSIDERATIONS FOR RAPID MAPPING IN DEVELOPING COUNTRIES

By Rupert B. Southard, Jr., Chief, Office of International Activities, Topographic Division, U.S. Geological Survey, Washington, D.C.

[*The original text of this paper, contributed by the United States of America, appeared as document E/CN.14/CART/68. This paper was originally prepared for the United Nations Conference on the Application of Science and Technology for the Benefit of Less Developed Areas, Geneva, 1963. It has been published in volume II,* Natural Resources, Minerals and Mining, Mapping and Geodetic Control, *by the Agency for International Development. This publication is on sale at the Superintendent of Documents, Washington, D.C.*]

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MODERN TECHNIQUES AND INSTRUMENTS FOR SURVEYS AND MAPPING

By Geo. D. Whitmore, Chief Topographic Engineer, U.S. Geological Survey

[*The original text of this paper, contributed by the United States of America, appeared as document E/CN.14/CART/89. This paper was originally prepared for the United Nations Conference on the Application of Science and Technology for the Benefit of Less Developed Areas, Geneva, 1963. It has been published in volume II,* Natural Resources, Minerals and Mining, Mapping and Geodetic Control, *by the Agency for International Development. This publication is on sale at the Superintendent of Documents, Washington, D.C.*]

Geodetic surveying

OVER-ALL ADJUSTMENT OF MADAGASCAR'S FIRST ORDER GEODETIC NETWORK[1]

Madagascar has the good fortune to possess a geodetic network covering almost the whole (63 per cent) of its territory. Although it was primarily established for mapping purposes, a certain number of favourable circumstances should, at the cost of some improvements and a new over-all computation, enable it to be provided with the precision necessary for a modern network.

The purpose of this document is to explain how it is intended to achieve this goal.

I. Details concerning the establishment and state of the Malagasy first order network before it was taken over by the Institut Géographique National

Without underestimating the work of the pioneers who, between 1895 and 1914, succeeded, in particular, in covering a great part of the Red Island with a geodetic network of hurried chains, the real start on a comprehensive triangulation began in 1924.

The leading spirit of this work was Colonel Laborde, whose strictly consistent and single projection for the Island makes computation of the triangulation possible from the first order. He operated the chain network by an *aggregate of several circuits*, the aggregate being calculated by least squares with the help of an original, simplified method which he called the "link method".

[1] The original text of this paper, submitted by the Malagasy Republic, under the title "Compensation d'ensemble du résaux géodésique de premier ordre de Madagascar", appeared in French as document E/CN.14/CART/34.

The method is no longer of more than historic interest but it enabled him to make the best use of his limited means for making calculations.

The whole chain network, the computation of which was completed in 1946, supplies a system of rectangular co-ordinates which will henceforth serve—except for limited local rectifications—as a base for all subsequent work (complementary first order, detail and surveys).

This network, which has the great merit of being *homogeneous*, does, however, present certain defects of which its promoter was aware. Quite rightly, however, he regarded it as adequate, from the point of view of the practical geodesy necessary for the regular map on the scale 1:100,000.

The main points still requiring improvement are :

Control of the primary azimuth, which is not sufficiently precise;

Addition to this single azimuth of other reorientation measures together with new measures for reduction to scale, to complete the three former measured by wire;

A certain number of partial remeasurements of triangulations in order to remedy local deficiencies which could not be improved in Colonel Laborde's time because of lack of time and means.

The average quality of the former work is nevertheless high enough for these measures to remain limited.

II. Improvements made by subsequent work and preparations for the general adjustment (1945-1962)

Since 1945 the complementary first operations have been conducted with a Wild T.3 type devices and by operators whose training is supervised by the Institut géographique national (National Geographical Institute) which is responsible for Madagascar's Geographic Service.

To provide for future needs, and despite the desire for efficiency, which necessitates the appreciable increase in cartographic equipment needs between 1945 and 1960, the operators have been given precise instructions to conduct, parallely, regular first order geodetic work and more expeditious utilitarian geodetic work of lower orders. At the same time, when work is being effected in the neighbouring virgin land, the triangulations which are recognized as deficient are systematically replaced by new triangulations.

Since 1950 the broad guiding lines of the preparation for the over-all adjustment have been outlined

Redetermination of the primary azimuth;

Establishment of at least two azimuths to the north and to the south;

Establishment of a fourth base to the south of the Island;

Inventory of former work to be redone.

It is expected in particular that amplification of the three former bases will be resumed together with computation by large blocks, the core of which would be constituted by the more recent 1° OC observations for the *main defect of calculation by circuit is still that it causes the better quality central zones to absorb the restrictions caused by localized faultiness in the chains.*

In 1958 a fourth base was measured with a 20 m invar wire in the south-west, with a precision estimated at 1:200,000, account being taken of the amplification.

At the end of this 1945-1962 period, the first order triangulation (together with the major part of the geodetic coverage for cartographic purposes) was *practically complete.*

The time has thus come to initiate the over-all adjustment computation programme, taking the maximum advantage of new possibilities afforded by:

The *tellurometer* for reduction to scale (rapidly and less restrictive measuring conditions, for a precision hardly less);

Electronic machines for the adjustment computations (time-saving and greater possibility of treating large over-all blocks).

III. Description of the outlines of the definitive project and implementation plan

The main purpose of the comprehensive adjustment is to obtain, with a global and more homogeneous precision over the whole of the territory, the base points necessary not only for the base map but also for all work of scientific interest which requires a sound "geometric frame".

This adjustment should make it possible to obtain almost everywhere a precision relative to 1:50,000 (i.e. better than one metre in 30 or 40 km—average value of a first order side), which is not the case at present in a certain number of zones, due, particularly, to the way in which the former computations were made.

In order to reduce to a minimum the operations which should serve as a base for this adjustment, and therefore the costs involved, it was decided, while increasing base and azimuth controls:

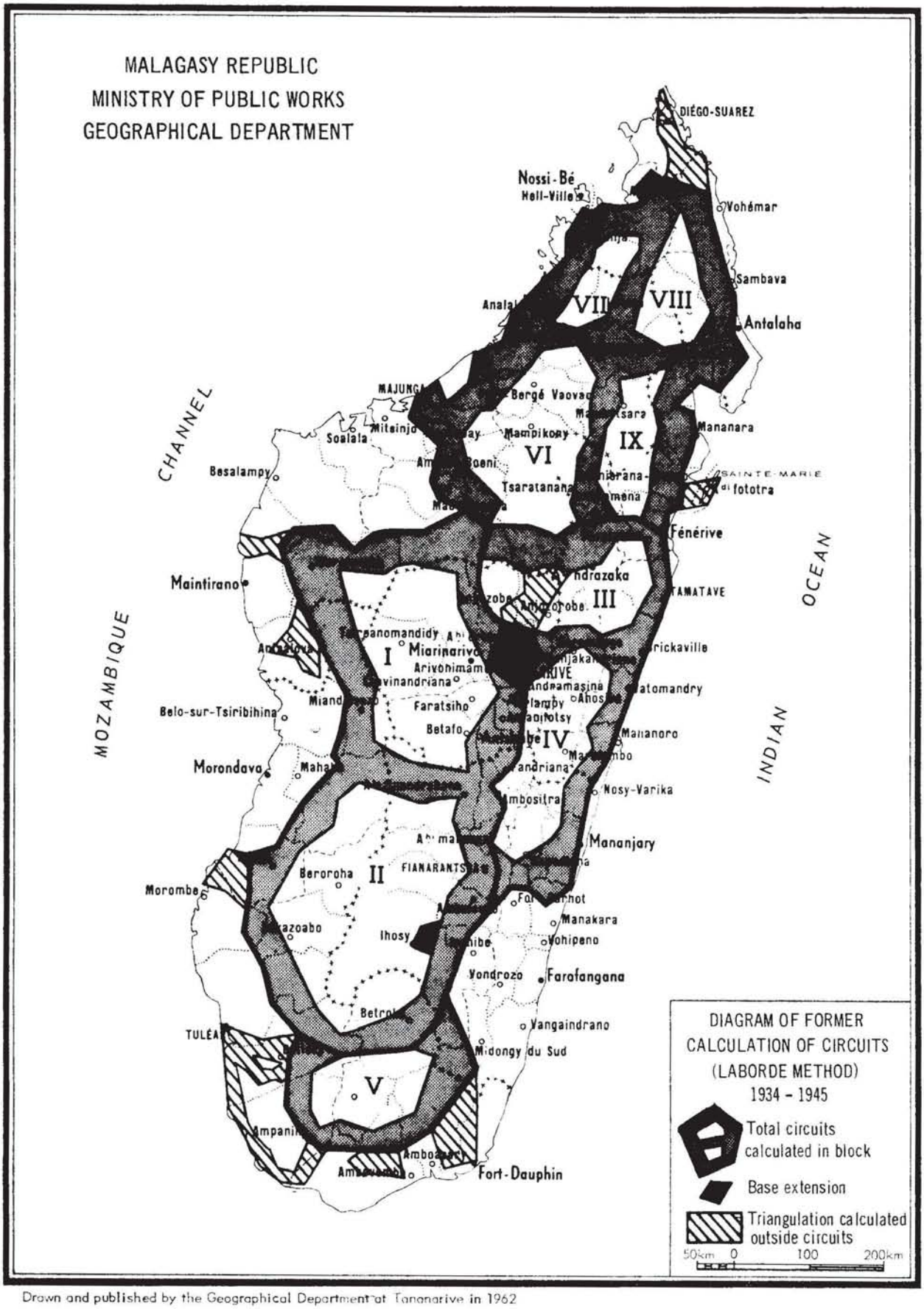
To exclude the adjustment proper of inferior quality coastal areas, because it would be too costly to resume in the immediate future and could always be computed, locally, later from the adjustment;

To include certain former lower quality chains in the blocks, by cutting up the blocks in such a way that the repercussion on the whole is negligible;

By foregoing the improvement of the amplifications of the former bases, the resumption by the least square method of the computation from former observations making it possible to ensure 1:200,000.

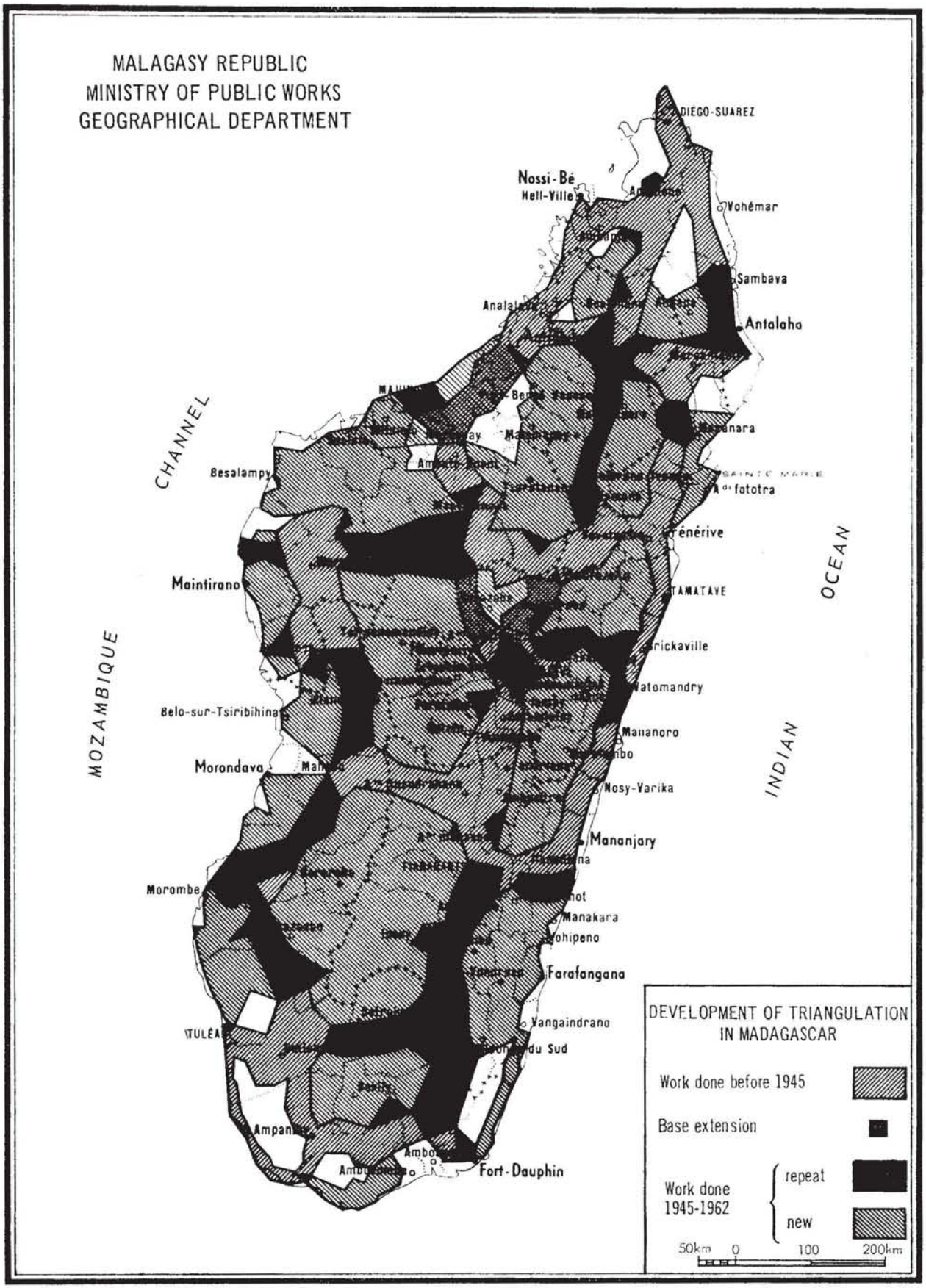
Finally, only two former chains, to the south and north of Tananarive, will be surveyed, the first from 1961, the second started in 1962, together with a part of the coastal chain near Majunga.

Reduction to scale will be ensured either by direct measuring, or by slightly broken segments on *tellurometer*, of 9 first-order sides, the site of which has been selected, in



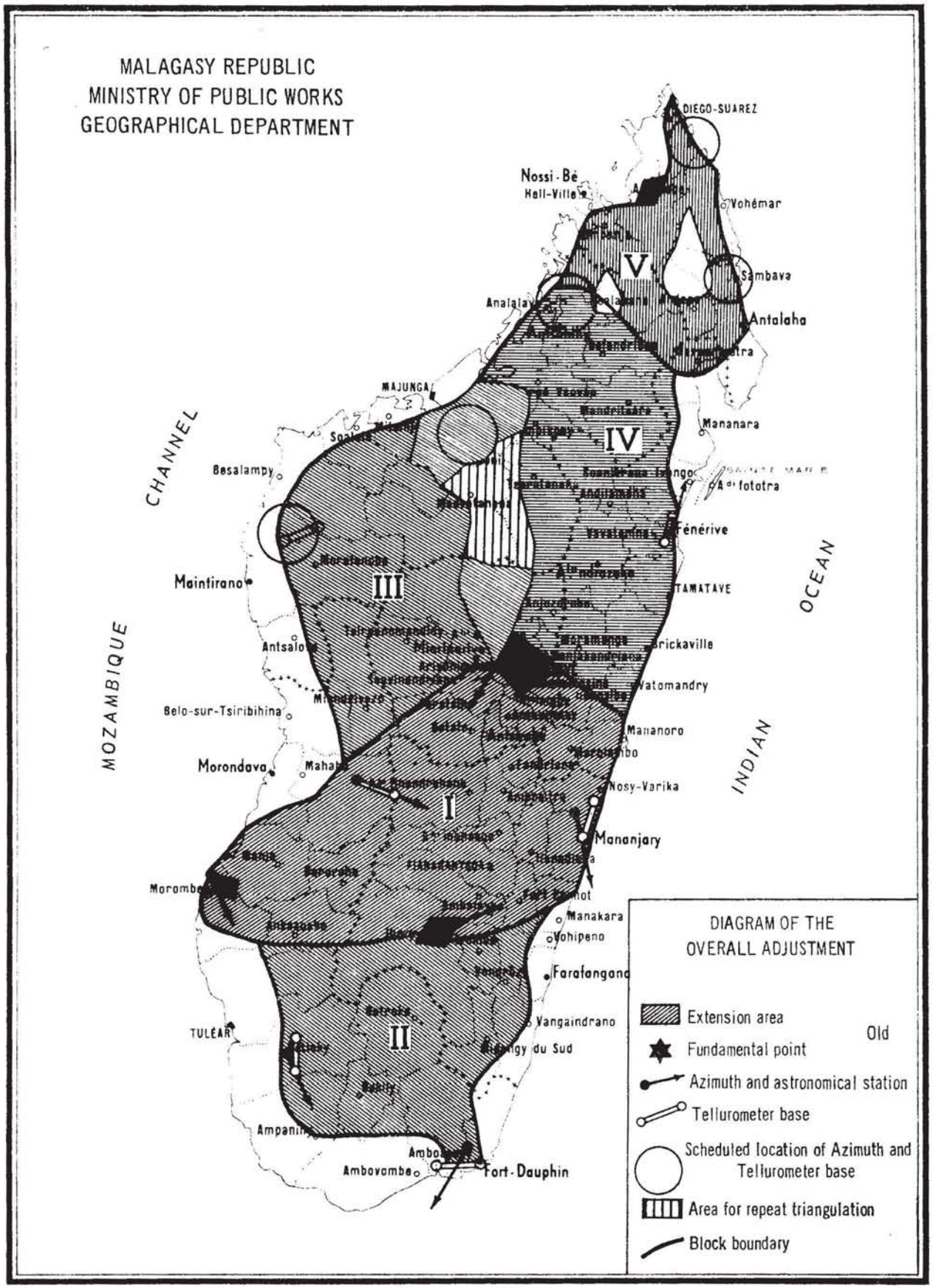
Drawn and published by the Geographical Department at Tananarive in 1962

Madagascar : Diagram of former calculation of circuits



Drawn and published by the Geographical Department at Tananarive in 1962

Madagascar: Development of triangulation



Drawn and published by the Geographical Department at Tananarive in 1962

Madagascar : Diagram of over-all adjustment

such a way as to furnish, with the three former bases and the 1958 base, a regular network of sides recognized at an average distance of 300 km.

In 1961 and 1962 seven measurements were taken in the south and centre of the Island, with a precision estimated at approximately 1:200,000, measurements which revealed, by comparison with the network in its present state of computation, scale discrepancies reaching 1:15,000 at the ends.

The scale control programme will be completed in 1963 by three other measurements in the northern part of the Island.

The *fundamental geodetic point*, the Tananarive Observatory, should be maintained. From 1957 to 1959 the longitude station of the International Geophysical Year controls and improves its co-ordinates.

In order to counteract the influence of an absolute deviation from the vertical at this point, doubtless quite probable, it is possible that at the time of the over-all computation an average orientation and an average position with respect to the reference ellipsoid will be adopted, both being calculated on the total number of astronomic stations.

In addition to the re-observation of the *initial azimuth* of Tananarive in 1962 at the same time as two new astronomic stations on two first order points near Tananarive, seven Laplace stations were observed in 1961 and 1962, five others are planned for 1963, on the Wild T.4 astronomic impersonal micrometer theodolite, with a precision which may be estimated at 1 or 2 centesimal seconds, near the bases or lines measured on the tellurometer.

At that time a regular network of sides and azimuths, approximately 300 km apart, will be available; this will make it possible, as and when the dismantling of the former work and the limited rebuilding observations are completed, to entrust the over-all computation of the network to the *IGN electronic workshop*.

For ease of computation, the network was divided into 5 main blocks, in relation to the reorientation and reduction to scale positions; it will be preferable, however, to treat this computation by the liaison equations method, known as the Pranis-Parnievith method, so as to obtain the final result as if it had been effected by a single unit.

The projected cutting up gives:

I. *Centre-south block* of 190 points with 5 base-azimuth pairs.

II. *South block* of 90 points with 2 base-azimuth pairs based directly on the preceding.

III. *North-west block* of about 110 points and 2 base-azimuth pairs.

IV. *North-east block* of about 150 points and 2 base-azimuth pairs.

V. *North block* of about 90 points, based directly on the preceding with 1 base-azimuth pair, 1 isolated base and 1 isolated azimuth.

Once all these 630 points have been adjusted, the first order points (130 for the south and 110 for the north) remaining unintegrated in the adjustment, because of their determination diagram or the lower quality of observations, will be computed by small blocks of 30 to 50 points, together with the whole detail triangulation a large part of which might, doubtless, be adapted by graph.

The over-all adjustment proper, which could doubtless be completed by the end of 1964, and a part of the adaptation computations, depend on electronic machines and programmes developed by the technical office of the Institut géographique national in Paris which will thus lend its technical assistance to the modernization of the Malagasy base network

Upon completion of this comprehensive work, the Island of Madagascar will have at its disposal a more homogeneous triangulation network which will have been freed of the main distortions which at present prevent it from supplying everywhere a sufficient base for the local surveys on scales above 1:50,000 and for cadastral work.

Documents attached: three diagrams:

Diagram of the former computation of circuits (Laborde method) 1934-1945;

Development of triangulation in Madagascar;

Diagram of the over-all adjustment.

THE CURRENT PROBLEM OF GENERAL LEVELLING IN THE CONGO (LEOPOLDVILLE)[1]

General precision levelling in the Congo, which was begun in 1954, extends over routes which at present total more than 13,000 km.

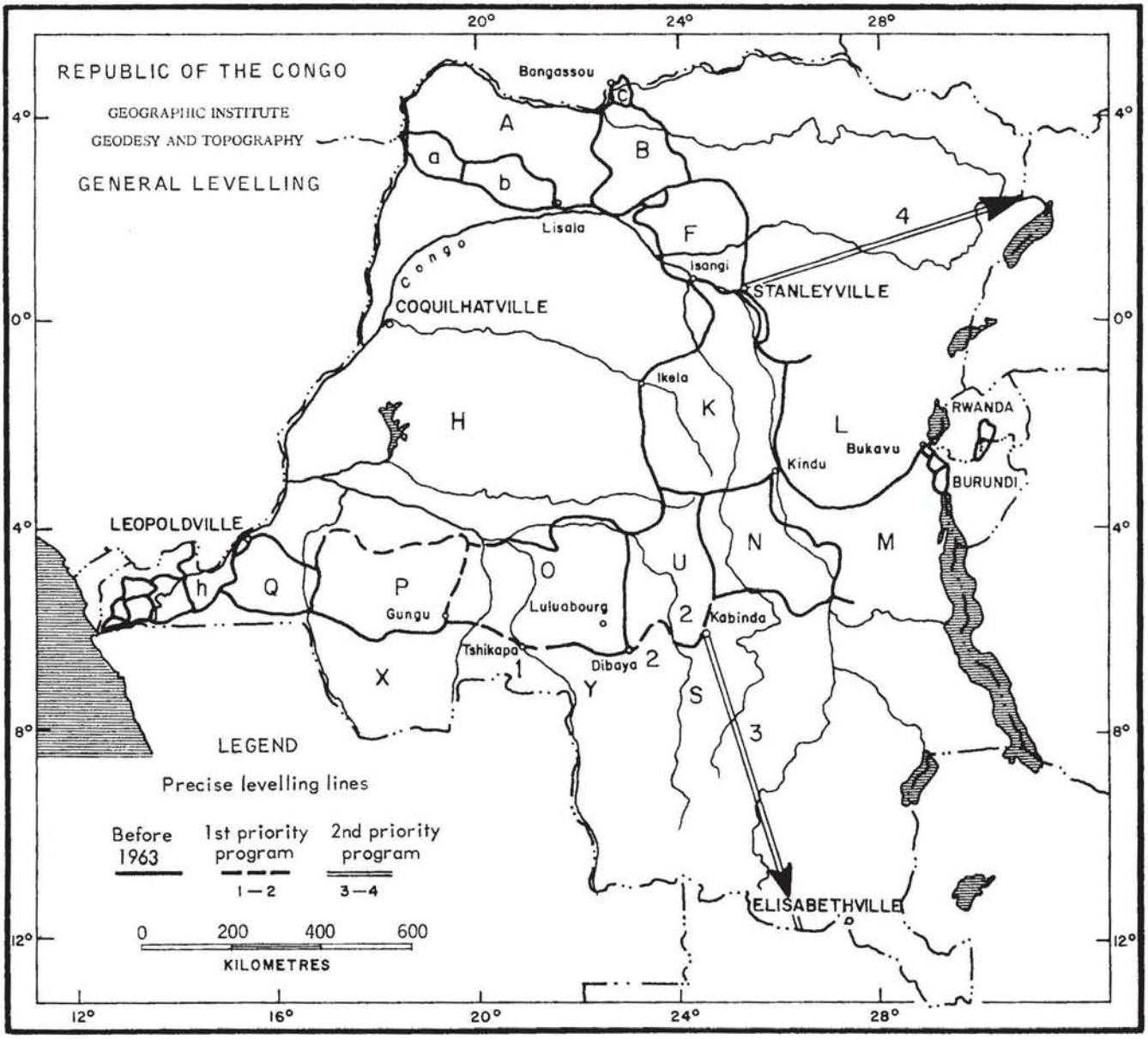
The surveying equipment is composed of Wild N3 levels and of levelling rods made by the same constructor.

The type of mark used, set in the ground at intervals of one every three kilometres, consists of a benchmark of copper with a round head, embedded in the upper surface of a cubic cement base with sides 30 cm. long, all of one piece with a plinth of some 250 dm^3 cemented into the ground.

The tolerance accepted for the deviation between the measurements taken when "Going" in one direction and when "Returning", for a particular section, is $4\sqrt{DK}$ mm, DK being the length of the section levelled, evaluated in, kilometres: depending upon the terrain, DK can vary between 1.5 and 3.

The levelling discrepancies are corrected by adding the theoretical orthometric corrections. Closures of levelled circuits (loops) are considered abnormal when they exceed

[1] The original text of this paper, submitted by the Congo (Leopoldville), under the title "Le problème actuel du nivellement général au Congo (Léopoldville)", appeared in French as document E/CN.14/CART/48.



Republic of the Congo: General levelling

$4\sqrt{DK}$ mm., DK being in this case the length of the circuit in kilometres.

With the exception of loop *K*, where a closure of 395 mm. occurring for 1,360 km. surveyed seems to indicate the existence of a glaring error, which still has to be tracked down, the ten or so loops surveyed entirely on Congolese territory and closed, up to the present date, with lengths varying between 200 and 1,500 km., have resulted in closures which, when dividing by $\sqrt{DK}$ range from 0.2 to 4 mm., the average being 2.0 mm.

Loop *M*, of 1,680 km., closes at 223 mm. on the surface of Lake Tanganyika; loop *h* (530 km.) closes at 144 mm. between Mindouli and Brazzaville; and loop *A* (1300 km. inside the Congo) closes at 180 mm. between Bangui and Bangassou, according to the provisional data supplied by the IGN in 1959.

An anomaly is to be found in the fact that the heights of Brazzaville and Mindouli, which are derived from the IGN levelling with zero at Pointe-Noire, differ on an average by 56 cm. from those arrived at by the IGC levelling with zero at Banana. The latter zero, taken incidentally from a scale for the roadstead, would thus be these 56 cm. higher than that of Pointe-Noire. The IGC will get in contact again with the IGN on this subject, the zero at Banana being perhaps not comparable with that at Pointe-Noire (mean tide gauge).

Probably the question of the closure of loop K alone will necessitate a resumption of field-work, which is provided for in the programme given below.

In 1962 plans were made to secure the general levelling East-West junction by terminating the survey of Gungu lines *OP* and *OH* at the river Loange where the previous surveys had ended. The preliminary reconnaissance having revealed that all the embedded marks to be surveyed and those surveyed as far as Port-Francqui at least, has been destroyed, the junction planned by this way had to be abandoned.

It seems, however, that the solution by line *O Y* is possible, the *OY* marks to the west of the Loange having been recognized as intact; further to the East, the information at hand allows some optimism, in this connexion at least. It was decided, moreover, that there a model-mark of the average density of 1 per 10 km. instead of the usual 1 per 3 km. would suffice, the aim being to ensure an East-West unction as soon as possible.

That being so, a levelling mission has just been re-organized; it has been assigned the task of surveying section 1 (see diagram), which would make possible a first simple East-West liaison.

If this work can be successfully completed, rather than seek the security of the total *PX* and *PY* survey by surveying the closures of the circuits *P* and *O* in accordance with the previously planned itineraries which would necessitate delimiting once more the destroyed marks referred to above and mark out others of the northern section of circuit *P*, it is planned to make a rapid control survey of lines *PX* and *OY* at the automatic Zeiss Ni2 level.

In the meantime, it is hoped that, by the 2-2 survey, circuit *U* will have been closed, a move which would, moreover, furnish another element for further localizing the error presumed to exist on loop *K*.

While the search for this error would also be made on the Zeiss Ni2, it is hoped that liaison 3 towards Rhodesia would be undertaken.

It is only then that a liaison 4 towards Uganda, to the north of Lake Albert, could be envisaged.

The purpose of this programme is to enable the various precision levellings in Africa, where the Congo occupies a central position, to unite more junctions and assist unification.

The trigonometric levelling of the Congolese triangulated network, cross-connected at several points with the precision levelling, could thus be improved and its reference zero standardized.

The carrying out of this programme does, however, present difficulties resulting from the situation in the interior of the country (supplies, spare parts for the transport, state of roads, and so on) which still prevents the ground work missions of the Institut géographique du Congo (Congo Geographical Institute) from functioning with the normal degree of profitability.

In order to solve these difficulties it would be desirable for the United Nations, which supports the Congo in general matters, to take an interest in the IGC, particularly with respect to the precision levelling programme just outlined. It seems appropriate that the programme, which forms part of African Geodesy, should be brought to the attention of the Cartographic Conference for Africa not only as a technical subject but also with the prospect that it might later, on the recommendation of the Department of Economic and Social Affairs of the United Nations, lead to specific assistance on the credit side of the United Nations operation in the Congo.

PRACTICAL APPROACHES TO THE ESTABLISHMENT OF GEODETIC CONTROL[1]

By Capt. Lawrence W. Swanson, Assistant Director for Physical Sciences, U.S. Coast and Geodetic Survey

Purposes of geodetic surveys

In proceeding with the mapping of undeveloped areas, the first consideration must be that of geodetic control. Adequate mapping operations could not be performed without a suitable geodetic framework on which to plot and reference the physical assets and neutral resources of a region. And the development of these resources is further dependent on geodetic control. Horizontal and vertical control surveys are prerequisites for the layout and contruction of cities, highways, railroads, airports, pipe and transmission lines, and hydroelectric, flood control, and irrigation projects. The positions and elevations of engineering works such as these must be placed on a common geodetic framework, else undue confusion would arise.

A firm geodetic network is also necessary for the delineation of national and provincial boundaries and for the survey of public and private property lines. The survey coordinates defining the position and elevation of a geodetic control station and the azimuth from the station to another control point provide the necessary data for a local engineer or land surveyor to commence and terminate his surveys and tie them to the national network.

The scientific ramifications of geodetic control must not be overlooked. Horizontal and vertical control combined with astronomic and gravimetric data provide an opportunity for investigations of the size and shape of the earth, and of the earth movement and other geophysical research.

Since geodetic control is the first requirement for mapping, which in turn is necessary for the orderly development of a region, it is obvious that the early establishment of geodetic control is of prime importance in a developing area. Horizontal control, if properly and accurately established, can serve its purposes just as well a century or so after its establishment, without continual revision. Vertical control also may serve its function for many years, but in areas known to be changing in elevation due to removal of underground water, earthquakes, or other causes, a periodic programme of relevelling might be necessary.

Horizontal datums

Before computations of geodetic surveys can be commenced, both references surfaces and datums must be determined. The problem of establishing a datum for horizontal control will be discussed first.

A horizontal geodetic datum is defined by five elements: the latitude and longitude of the original or initial station; the azimuth of a line from this station to another point in the net; and two parameters defining the reference ellipsoid. The ellipsoid of revolution is used as the surface on which geodetic surveys may be computed, as this is the mathematical figure most closely approximating the shape of the geoid, or sea-level surface of the earth. However, in the past, different countries of the World have used ellipsoids of various sizes and shapes as the reference surfaces for their horizontal control computations. When this occurs in neighbouring countries, the disadvantage of not being able to make direct connexion between the two networks results. Furthermore, two adjoining nations may use the same reference ellipsoid, but their individual control networks may very well be referred to local, independent origins. Again, geodetic computations could not be performed between the networks of the two countries.

It is preferable that all countries on the same continent base their surveys on a common geodetic datum. In Africa, the 30th Meridian Arc triangulation, computed on the Clarke 1880 ellipsoid, is the backbone of the continental control network. All African countries adjacent to this triangulation have an established datum to which to connect their surveys. Those countries located in the western or north-central sections of Africa that could not conveniently connect their control to 30th Meridian triangulation must adopt a provisional origin from whence to commence their computations. The positions of these control stations could be adjusted to the continental datum after international ties to the 30th Meridian Arc are accomplished. In a case of this kind, although the reference ellipsoid is defined, the problem remains to establish a provisional origin.

The simplest means of determining an origin is to establish a control station approximately near the centre of the country, observe the astronomical coordinates of the station and the astronomical azimuth of a line from this point to another control station, and use the observed astronomic coordinates and azimuth as geodetic coordinates and azimuth on the reference ellipsoid. The geodetic computation of other stations in the net may then proceed. The computed positions of all of the stations will be correct with respect to each other, but the net as a whole will not necessarily be positioned and oriented correctly on the surface of the earth by the amount of the absolute deflection of the vertical at the origin. In using the astronomic data as geodetic data at the origin, the deflection of the vertical is assumed to be zero; that is, the normal to the reference ellipsoid is assumed to coincide with the local direction of gravity, which is rarely the case. This method of establishing a datum is satisfactory only as a temporary expediency.

The determination of a geodetic datum may be improved somewhat by using a procedure similar to the following: As in the previous method, a station is designated as origin, an astronomic latitude, longitude, and azimuth is observed, and the geodetic network progresses outward from this point. The geodetic positions of the control points are calculated on the adopted ellipsoid. Furthermore, astronomic positions are observed at selected stations, well distributed throughout the net. At each of these stations, the difference between the astro-

[1] The original text of this paper, contributed by the United States of America, appeared as document E/CN.14/CART/65.

nomic and geodetic latitude and the astronomic and geodetic longitude are computed. The positions of the origin station is then so adjusted that the algebraic sum of the astronomic minus geodetic differences throughout the net is a minimum. This method has been practiced by many countries in the past.

By utilizing Shoran or Hiran trilateration, a provisional datum may be established quite rapidly. Several stations about four of five, spaced from 200 to 500 kilometres apart and forming a relatively symmetrical figure, are selected for astronomic observations. All possible lines connecting these points are then measured by the Shoran line-crossing technique. The figure is then adjusted and held fixed geometrically. One station is selected as the origin, using the astronomic coordinates as the geodetic coordinates. The geodetic positions of the other stations in the net are then computed. Finally, the coordinates of the stations are adjusted by minimizing the algrebaic sum of the astronomic and geodetic latitude and longitude differences. This method is recommended when a rapid establishment of control is necessary for preliminary mapping.

Vertical datums

A datum for vertical control is the next consideration. Mean sea level is a convenient vertical datum, but because of the effects of winds, ocean currents, atmospheric pressures, configuration of the coastlines, and other disturbing elements, an exact determination of ideal mean sea level is impossible. The best we can do is to average the varying height of the sea at selected stations along a coast over the full tidal cycle of 19 years. This is done by establishing a system of tide gages, so designed that the rise and fall of the tide can be continually and automatically recorded. Standard tide stations may be spaced about 150 km. apart along a coast line if the tidal characteristics do not vary much. There may be many areas, however, where the tidal conditions are quite different at localities less than 150 km. apart, and in these cases the spacing of the tide stations must be reduced. Temporary, portable tide gages may be installed to supplement the standard tide stations. Local mean sea level can be determined from just a short series of tidal observations at a temporary station by comparing the observations with the record from the nearest standard gage where the tidal characteristics are similar. Because of the coastal areas, it is important that tidal data from the various standard gages be obtained during the same period of time.

Levelling operations may, of course, be started before a local mean sea level has been established. An adequate provisional datum may be obtained from a one-year period of tidal observations.

In a landlocked country where a sea-level connexion is not available, a particular bench mark may be assigned an arbitrary elevation and used as a datum until such time that a tie to the levelling of the neighbouring country can be made. In the case of two adjoining countries bordering the sea, each with a level net based on local tidal observations, not only should the necessary levelling ties be made, but it would be advisable to have one least-squares adjustment of the levelling of both countries, in order to bring about consistency and not have two elevations for any one mark along the border.

Horizontal control—triangulation

Geodetic triangulation has long been recognized as an efficient method for extending accurate horizontal control surveys over large areas of the earth's surface. A system of triangulation consists of a network of triangles, the vertices of which are marked points on the ground. All angles are accurately measured with theodolites, and the lengths of the sides are computed successively through chains of triangles, starting with a side that is actually measured on the ground. These measured sides, or base lines, are inserted at intervals to maintain accurate scale. Also, the azimuth of an occasional triangle side is observed astronomically to maintain accurate orientation.

Triangulation may be classed as either arc or area. Arc triangulation is composed of chains of braced quadrilaterals and central-point polygons, and is widely employed for first-order, or primary, control networks. Area triangulation is usually, but not necessarily, of a lower order of accuracy. It is composed of a continuous network of triangles and is often used to fill in the areas between the arc triangulation.

In the larger countries, a system of arcs is desirable for the primary triangulation framework. Observing progresses fairly rapidly, and the arcs can be so spaced and located that the areas in between may be readily filled in at a later date.

When selecting the types of figures to be used, a prime requisite is that there must be at least two routes through which to compute the lengths. In general, there should be no overlapping of figures and no excess of observed lines beyong those necessary to obtain a double determination of every length. An exception to this may occur when expanding from a base line. Braced quadrilaterals and central-point figures with all stations occupied are most suitable for arc triangulation. The scale error must be kept within certain limits as determined by the strength of figure, which is an expression of the relative precision of computed lengths through the scheme, based on the geometrical shapes of the figures and the number of conditions. If the allowable strength of figure is exceeded, a base line must be added or the figures revised and strengthened. All figures in the scheme should be about the same size, and extremely long lines should be avoided. The topography of the area may be the most important factor in selecting the type of figure to be used. Economy and the rate of progress should also be a consideration.

The lengths of triangulation lines may range from 15 km. to 50 km., depending on whether the work is in flat or mountainous country. The interval between arcs of triangulation on the geography of the region and on the type of control that will be used to fill in the gaps. In a large country, it would be advisable to have primary arcs follow the coastline and/or the national boundaries, with the interior divided by other primary arcs forming rectangles about 200 km. by 300 km. Base lines and Laplace stations should be placed near the intersections of the primary arcs. Where this cannot be done, it would be desirable to have a base and Laplace azimuth station at least every 300-400 km. along the arcs.

In a small country of a few thousand square kilometres, a continuous net of triangles, rather than a system of arcs, would probably be most practical. In a country about 200 by 300 km. there might be a base and Laplace station at each end, and in a country 300 by 300 km. a base and Laplace station at each corner might suffice.

The exact layout of any triangulation will depend, of course on the topography of the region. Triangulation stations must of necessity be located on the high points. It is wise to have a reconnaissance party select the station sites and lay out the scheme of triangulation before the triangulation party commences its work.

The primary framework should be as accurate as possible, and should fall under the category of first-order triangulation. Over-all length closures of 1:100,000 would be specified in this case, which is not an unreasonable goal. A nation's triangulation net should be connected to the geodetic control of the adjoining country, if possible. In fact, it might be benefical to plan triangulation on an international basis.

Trilateration

The classical methods of geodetic triangulation may not be adaptable or practical for all areas. Traverse and/or trilateration may be necessary in lieu of, or in conjuncton with, triangulation. Trilateration is a method of extending horizontal control where the sides of triangles are measured rather than the angles as in triangulation. The development of Shoran and its more accurate counterpart, Hiran, has made possible the extension of geodetic control over vast, inaccessible regions and across long stretches of water. Trilateration may also be used to extend a geodetic datum to areas far removed from well established datums. Hiran or Shoran trilateration has been undertaken in northern Canada, in the Caribbean area, and in the North Atlantic to provide a geodetic tie between the European and American continents.

Shoran employs high frequency radio waves for the measurement of distance between an airplane and a ground station. In order to obtain the distance between two ground stations while continual observations and recordings of the air distances from each of the two stations to the airplane are taken. The minimum sum of the air distances is determined and then reduced geometrically to sea level to obtain the final ground distance between the two stations. One line measurement consists of two groups of six or eight line crossings, each at two different altitude levels. Utilizing this method, one line measurement will have an accuracy on the order of a few metres when the lines are between 100 to 500 km. in length.

A Hiran net should contain a large number of redundant lines for the purpose of giving it additional strength and for checking any lines which may have been affected by abnormal conditions.

A framework of Hiran trilateration may be established over large areas in relatively short order, and may be an ideal method for establishing control for small scale mapping in undeveloped countries. Geodetic triangulation or traverse will still be required at some later date to break down the long sides of the trilateration network. However, with a framework of Hiran trilateration, the triangulation or traverse may be initiated independently in different parts of the net, without subsequent trouble arising from the use of independent origins.

Traverse

Not only has the development of electronic distance-measuring devices made trilateration a practical reality, but the traverse has now come to the fore as an economical and acceptable substitute for triangulation.

The Tellurometer and Electro-tape are distance-measuring instruments which utilize radio microwaves to transmit measuring information between a master and remote unit. Measurements may be made through haze, mist, clouds, or light rain. The Tellurometer, when properly used, can yield second-order accuracy, provided the lines to be measured are at least 4 or 5 km. in length. It can also be used to scale first-order triangulation where the lines are over 20 km. in length; in this case at least two sides of a triangle are measured in order to guard against too large an error.

A Tellurometer traverse can often be run at reasonable cost through a country where triangulation would be physically or economically impracticable. Moreover, a Tellurometer traverse may be an excellent method for filling in the gaps between first-order geodetic control. Australia has used the Tellurometer extensively for subdividing the continent with first-order traverses. Tellurometer traverses have been used in the United States to provide control for the interstate highway system. In Kenya, a 650-km. first-order traverse, with legs ranging from 12 km. to 50 km. in length, was completed in just 26 days.

An important advantage of the traverse is the accessibility of the station marks. In order to provide lines of optimum length and to enable future work to be joined on easily, traverse stations still may have to be on hill tops, but they need not be on the highest points in the area, as is the usual case in triangulation. Traverse lines can often be located between hills close to lines of communication, on positions where the stations are easily accessible to future surveyors who may need them.

Laplace azimuths must be more frequent in a traverse than in triangulation if the azimuth accuracy is to be comparable to the length accuracy. With Tellurometer legs averaging 30 to 40 km. it is not unreasonable to aim at a Laplace azimuth at every station if high-order precision is desired. This was done in Australia. In other areas, however, the prevailing weather conditions may prohibit observing Laplace stations at such frequent intervals.

Another type of electronic device is the Geodimeter, a high-precision instrument which employs modulated light waves to measure distance. A major advantage of the Geodimeter is that it is well suited for the measurement of first-order base lines. Consequently, this instrument has almost superseded the classical taping routine. The time and cost of measuring a base line is greatly reduced, for the tedious clearing, staking and taping is no longer necessary. Furthermore, the Geodimeter makes it possible to establish base lines in areas of rough terrain where taping would be impractical or impossible.

The accuracy of the Geodimeter completes favourably with the accuracy obtained with invar tapes. Lengths of

lines have been measured with an accuracy of one part per million with this instrument. Ranges up to 30 km. (50 km. under favourable operating conditions) are possible with the larger models.

The Geodimeter can be used for traverses of very high accuracy. The United States plans to establish a system of super-grade Geodimeter traverses which will criss-cross the country in east-west and north-south directions. These traverses will upgrade the scale of the triangulation network and will provide accurate length control for the proposed satellite triangulation. The traverses, which will be established along the sides of existing first-order triangulation arcs, are designed as follows: At every other station along the traverse, a second station monument is erected about 25 to 50 m. from the main station, these points forming long slim quadrilaterals with the single-monumented stations. The short 25 to 50 m. length is taped, the long legs are measured with the Geodimeter, and all angles are measured. With this method, rigid checks are obtained for both length and angle observations as the traverse progresses. Laplace azimuths are observed at every other traverse station, usually the single -monumented station. Since the traverse legs are roughly 12 to 16 km. long, a Laplace azimuth is measured and a deflection of the vertical determined every 24 to 32 km. along the traverse. This method of laying out a precise traverse might well be used to extend control into virgin areas.

Vertical control

The classical method of determining elevations by spirit levelling remains today as the most precise method of extending vertical control. Spirit levelling is a slow, step-by-step process. In order to obtain high accuracy the lines of sight seldom exceed 100 m. Levelling lines must follow roads or railroads if at all possible; in regions where transportation routes are few, progress is much slower. However, this method of establishing vertical control must be used in any region where accuracy greater than that required for topographic mapping is desired. A new area should be covered with a network of first-order levelling lines spaced from 80 to 160 km. in both directions. Second-order levelling may then be used to break down the first-order loops if desired. Where vertical control is desired for mapping purposes only, and first- or second-order accuracy is not necessary, observing vertical angles over a triangulation net, or a traverse scheme, will provide adequate results. In fact, vertical angle elevations, for mapping purposes, should be obtained in any triangulation or traverse net that is being established in an undeveloped area.

Ethiopia control project

A modern example of a geodetic survey utilizing modern equipment and procedures for mapping of a developing area is the Ethiopia Control Project, undertaken jointly by the Imperial Ethiopian Government and the Government of the United States from 1957 to 1961. Precise horizontal and vertical control surveys were established in the 300,000 sq. km. area of the Blue Nile River watershed of Ethiopia. Twelve technicians of the Coast and Geodetic Survey, United States Department of Commerce, and approximately 60 Ethiopian nationals were assigned to this project. The technical operations of the project were under the direction of the U.S. Coast and Geodetic Survey. The Ethiopian employees were given on-the-job training in geodetic methods and procedures.

Over 4,500 km. of first-order triangulation arcs and over 3,300 km. of first-order levelling lines were established. Seven taped base lines, averaging 12 km. in length, were measured. Where an accumulation of the strength of figure value dictated the installation of a base line and no suitable sites for taping existed, Tellurometer measurements on all sides and diagonals of selected quadrilaterals were made. Tellurometer measurements were also used to locate additional stations by closed traverse methods.

Incorporated in the triangulation network were twelve astronomic latitude and longitude stations. Helicopters were used extensively for transportation of observing crews to the mountain-top triangulation stations. In general, triangulation stations were placed about 40 km. apart, a total of 365 horizontal control stations being established. Vertical angle measurements were taken to determine the elevations of all triangulation stations. Precise levelling was all double run. Bench marks were spaced between 3 to 5 km., a total of 960 bench marks established. All horizontal and vertical control points were identified on aerial photographs.

The surveys were connected to Sudanese triangulation and levelling in order that the 30th Meridian African datum and mean sea level elevations could be provided. In addition, connexions to existing triangulation in western Eritrea and in central Ethiopia, southeast of Addis Ababa, and a levelling connexion to Asseb on the Red Sea, were also accomplished. Horizontal control was computed and adjusted on the Clarke 1880 ellipsoid.

This project will contribute greatly to the development of the Blue Nile River basin by establishing the geodetic control so essential for mapping and for water resources investigation. Additional control may be readily expanded from this framework if more detailed mapping is desired in the future.

Summary

The new electronic distance-measuring instruments and the precise theodolites and levels now available provide the emerging nations with tools of high geodetic precision for undertaking accurate control surveys. With these tools, there is much flexibility for the planning of geodetic control. Furthermore, the aeroplane and the helicopter now provide economical and rapid means of establishing control in remote areas. Vertical control requirements may be satisfied not only by lines of spirit levelling but by trigonometric levelling over triangulation or traverse schemes. In planning a horizontal control network, triangulation, electronic traverse, trilateration, or various combinations of these methods can be adapted to best suit climate, terrain, accuracy demands, and economic conditions.

U.S. ENGINEERS' GEODETIC SURVEYS IN CENTRAL AFRICA[1]

By D. L. Mills, Chief, Department of Geodesy, U.S. Army Map Service, Washington 25, D.C.

Africa with an area of 30 million sq. km. is the second largest continent of the world, just over one-fifth of the entire land surface of the earth. In order to map this huge continent, it is desirable to establish basic control over the whole area, preferably on a single datum. This control may be sparse, but it must be sufficiently accurate to permit expansion to the required density in those areas that are selected for mapping at larger scale.

Fortunately, there were men of great foresight in Africa who laid the ground work on which the present generation may confidently continue to work for the economic development of this vast continent. It was Sir David Gill who as early as 1879, when he was appointed H.M. Astronomer at the Cape Observatory, recommended the plan of a great triangulation chain along the 30th Meridian, starting from the Cape and eventually to reach as far as Cairo, Egypt. This chain was to be the backbone on which in the future all geodetic control in Africa could be based. The first section was started in 1883 from Port Elizabeth, South Africa, and since then the work on this great arc of more than 6,000 km. in length has been carried on intermittently against many odds and to the lasting credit of many geodesists who participated.

At the end of the Second World War, there remained an unfinished gap of approximately 1,000 km. which extended from the Semliki flats at the southern end of Lake Albert in Uganda and the Congo to the Nuba Mountains in the Southern Sudan. The most difficult section of this gap was the crossing of the Sudd region of the Sudan, that low area bordering the Bahr el Jebel between the hills that end near Juba and the Nuba Mountains northwest of Malakal. Here, for a distance of 500 km. there are no hills and no perceptible changes of elevation. Moreover, during the later weeks of the rainy season much of the land is under a few inches of water. This area was long considered virtually impassable for survey, but in 1929 it was found that a feasible route existed east of the Sudd region.

At the Commonwealth Survey Officers' Conference in London, July 1951, the completion of the triangulation arc through this gap was discussed. The discussion continued outside of the Conference and led to the submission of a proposal for the completion of the Arc of the 30th Meridian to the governments of the Sudan, Uganda and the Congo. The proposals provided that a survey party from the United States Army Map Service would co-operate with the Survey Departments of the other countries in a project to complete the triangulation through the gap.

At this time, the Sudan Survey Department had completed the triangulation of the Arc from the connexion with Egypt southward to the northern limit of the Sudd. They had given much thought to the problems to be encountered in extending the operations farther south. Perhaps the most important of these was the difficulty in the transport of steel survey towers to the station sites. To provide for the successful passage of heavily loaded vehicles over the clay-hummocks which built up during dry weather around the roots of close-spaced tufts of grass, it was recommended to use a heavy tractor with a cutting blade to make the routes to the tower sites passable. Two caterpillar tractors with angle-dozer blades were shipped from America and proved invaluable in the operations.

Another important factor in planning the operations was the short duration of the dry season which is often limited to a four-month period from December through March. Furthermore, as the flood waters of the river recede from the low areas progressively from south to north, the station sites near the Bahr el Zeraf and its junction with the White Nile are flooded until late in January. Therefore, it was decided to start the operations in the hills near Juba and proceed northward. At least half of the Sudd region should be crossed during the first dry season, at the end of which the party would move into Uganda and the Congo and work northward again to Juba.

The Army Map Service in Washington set out to acquire the equipment and supplies for shipment via Port Sudan to arrive in Juba by mid-November 1952. The American personnel consisted of a party of seventeen, including two automobile mechanics, two bulldozer operators as well as two steel tower builders. In December the triangulation party established its camp about five miles northeast of the Luluba base. Here, as throughout the operations where steel towers were used, everyone worked from a central camp to which all personnel and equipment, except the bulldozers, were returned daily. A large force of the Sudan Survey Department, encamped nearby, included drivers, lightkeepers, tower builders and a permanent crew of laborers.

The equipment included twenty-three vehicles of which all but one were standard U.S. Army stock with four-wheel drive and dual transmission. The ample stock of spare axles, motors, and transmissions was drawn on rarely and then only for replacements while minor repairs were being made on the original. The steel survey towers were of the Bilby type developed by the U.S. Coast and Geodetic Survey, consisting of inner and outer towers of triangular cross-section. Of these, the Sudan Survey Department supplied from their stock eight 103-foot towers and four 50-foot towers. Five additional towers were shipped from America.

The observing kit for tower triangulation consisted of a Wild T-3 theodolite, a pair of cast aluminium tribrachs which provided the support for the theodolite and a protective canvas designed to fit the tower. The observer also carried lights to direct the other observing parties, another light with which to signal the lightkeepers, a small headlamp for the recorder, and dry cells in quantity sufficient for the night's work. In addition, he normally carried an optical plummet to centre the lights and the theodolite over the station.

[1] The original text of this paper, contributed by the United States of America, appeared as document E/CN.14/CART/85.

The reconnaissance in the Sudd region proved to be largely a matter of navigation for a predetermined distance on the proper magnetic bearing from a previously located point. By avoiding the rare groves of tall trees, it was possible to locate the stations on a fifteen-mile east-west and a thirteen-mile north-south spacing and have intervisibility between 103-foot steel towers. The approach to the preselected location was by compass-and-jeep traverse, first along the highway, then in the wake of the bulldozer as it cleared the route. Distances were read from the odometer on the jeep and the heading of the bulldozer was checked with a magnetic compass. A position accuracy af about half a mile was readily obtained.

The observations began in December on the hill stations of the Lulaba base expansion net. The Ayod base at latitude 8° North was selected as the closing tie for the season's triangulation work. This base is located on a strip of sandy soil extending some miles in a north-south direction through the surrounding black clay. The sandy soil provided a stable setting for the station monuments at the base terminals and thus a suitable tie line from which to start next years' work.

The direction method of observation as used by the U.S. Coast and Geodetic Survey for first order triangulation was adopted. Sixteen pointings each, direct and reverse, were observed on all main-scheme stations. Results obviously far from the mean were rejected and reobserved prior to the computing of the arithmetical mean of the sixteen observations. Results more than four seconds from this mean were then rejected and reobserved, and the final mean computed. The results on each station were then evaluated on the basis of the triangle closures and the side equation checks. The maximum triangle closure was limited to 2 seconds, the average triangle closure to less than 0.7 second.

All observations were made at night on lights operated with 1½ volt dry cells. Under favourable conditions observing was started as soon as all lights were visible. However, the dry season in the southern Sudan is also the season of grass fires. Days or nights without smoke and heat from a grass fire were rare. The results obtained on the few fireless nights during the first season gave evidence that this flat terrain with its uniform vegetation was ideal for good triangulation. Under these favourable conditions the triangle closures were small, averaging less than 0.4 second.

Upon completion of the triangulation of the Ayod base net in March the towers were dismantled and stored, together with the tractors, in the village of Duk Fadiat. All other equipment not needed for the triangulation in Uganda was returned to Juba and placed in storage there. The labourers recruited north of Bor returned to their home villages, while the Sudan Department drivers and their assistants departed for Khartoum.

In April, the move to Fort Portal, selected as the first camp in Uganda, was made in two convoys. The first, consisting of the light vehicles for the observing parties which could cross on all bridges and ferries, went via the Butiaba ferry. The heavy vehicles, detouring all ferries in Uganda and the Congo, travelled southeastward 400 miles to Busia near the Kenya border, thence westward 300 miles to Fort Portal. There, a de Havilland Beaver aircraft, with pilot and mechanic, was added to the party. Besides being very useful for reconnaissance, the aeroplane permitted close contact with the observing parties scattered in the mountains of Uganda and the Congo. Mail, messages and some light supplies were delivered by dropping them from the plane.

In early May, the Semliki base net, of which all of the five original stations had been recovered and to which a sixth station was added to strengthen the figure, was observed. Rain, fog and haze obscured the lowlands and clouds covered the mountains. These conditions improved only slightly during the three succeeding months. The greater part of the time on stations was spent in waiting for the lights which on the longer lines were never visible with the naked eye and seldom for long through the theodolite telescope. However, few nights were completely unproductive.

Messages were exchanged by signalling in international Morse code with the lights. Upon completion of the normal rounds of observations the results were signalled to the Number 1 observing party which quickly calculated the triangles and side checks. If the results satisfied the criteria, the observers were signalled to proceed to the next stations. If the checks were found unsatisfactory, instructions for reobservations were signalled to the observers whose results appeared to be poor, or, if the results varied widely, all parties were instructed to reobserve all lines.

The base camp was moved from Fort Portal to Irumu in the Congo, in July from there to Arua in Uganda, and in September north to Juba, Sudan. Observations continued under slowly improving conditions throughout June, July, and August. The observations completing the section from the Semliki base to the Luluba base were completed in late October. Four stations of the Luluba base net on which the previous season's observations had been affected by grass fires, were reobserved under more favourable conditions.

Early in December the highway north to Duk Fadiat was declared passable for light vehicles, and the bulldozer operators and steel tower builders proceeded north to put the tractors in condition and prepare to re-erect the towers at the terminals of the Ayod base. Shortly thereafter, the remainder of the party with the heavy vehicles moved from Juba to a selected camp site near Chieth, 40 miles north of Ayod. The observations could be made before the grasses dried sufficiently to burn freely and excellent results were consistently obtained. The over-all progress was rapid and the seven quadrangles between Ayod and the White Nile were completed in three weeks. With all the tower stations south of the Nile completed, the bulldozers and towers were ferried across the river at a spot about 20 miles west of Malakal. The river was now falling rapidly, all stations were accessible, and the observations were completed in very short order. The tie with three stations in the Nuba Mountains south of Abu Qarn base was made on the night of 27 January. The gap in the Arc of the 30th Meridian was closed.

The statistics of the triangulation completed during the two seasons, including reoccupation of 5 stations of the Semliki base net and of 3 stations of the Abu Qarn base net, is as follows:

Length of arc (kilometres)	1,000
Number of stations occupied	109
Number of tower stations	63
Number of directions observed	571
Number of triangles	253
Maximum triangle closure	2″.11
Average triangle closure	0″.58
Number of positive triangle closures	148
Number of negative triangle closures	99

Following are base-to-base closures representing the comparison of the measured length with the length computed in the field through the best chain of triangles after the directions were reduced to sea level:

Semliki base to Luluba base	1:310,000
Luluba base to Kwidok base	1:120,000
Kwidok base to Ayod base	1:114,000
Ayod base to line G93-G94	1:161,000

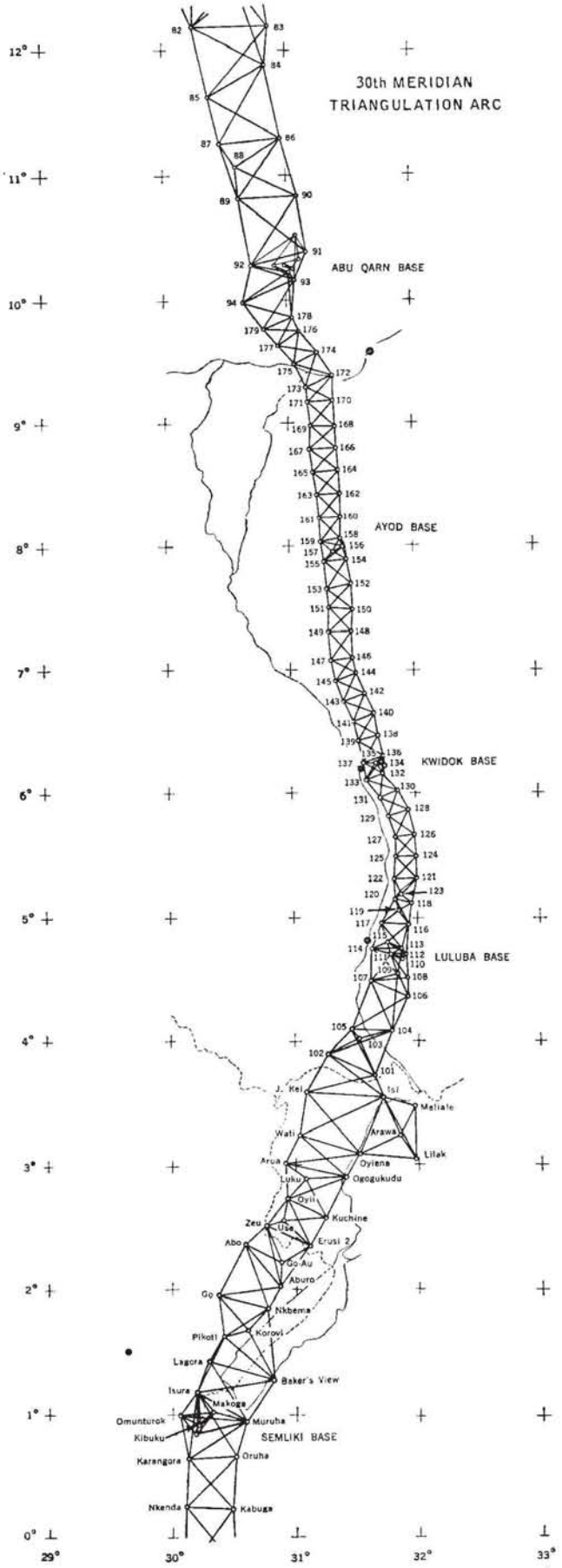
The completion of the African Arc of the 30th Meridian is a major contribution to the study of the figure of the earth. However, for this purpose it is necessary to carry out a simultaneous adjustment of the Arc in its entire length from Cairo to Port Elizabeth. To do this, a sufficient number of Laplace stations must be available with astronomically observed longitude in addition to azimuth and latitude. A large number of astronomical observations existed throughout the Arc, but mostly for latitude and azimuth, and very few for longitude.

For this reason, a co-operative programme was agreed upon in 1953 whereby a sufficient number of Laplace stations would be observed throughout the Arc for any subsequent adjustment. After completing the observations on 10 stations in Egypt, an American party consisting of five men accomplished the following observations in the central portion of the Arc: three stations in Uganda (Arua, Makoga, Buhungurua); four stations in Tanganyika (Nyamanyama, Kinyika, Wakole, Ntiri); and four stations in Northern Rhodesia (Kaseshya, Kabali, Chatuntile, Kanyaruwe).

Latitudes and longitudes were observed using the Bamberg Broken Telescope Transit with the following ancillary equipment: Hammerlund radio receiver model SP-600, Brush Oscillograph and Amplifier, Drum Chronograph (Gaertner type) and Sideral chronometers. Azimuths were observed with the Wild T-3 theodolite with the necessary accessory equipment.

The latitudes were observed by the Horrebow-Talcott method with approximately 24 to 36 star pairs for each latitude. The longitudes were observed by the meridian transit method, with 6 to 9 time sets for each longitude. A time set consisted of 6 to 8 stars, half being observed north and half south of the zenith. Each time set was bracketed by radio time signals received from Washington, D.C., Rugby, England, or Johannesburg, South Africa.

Astronomic azimuths were observed by the triangulation party for Laplace stations in the Sudan south of Abu Qarn base and at stations Arua and Makoga in Uganda using Polaris. At approximately 3° north latitude Polaris was clearly visible above the horizon. East-West stars at elongation were observed for the azimuths in the equatorial belt. In Northern Rhodesia the southern circumpolar star Sigma Octantis was used.



30th Meridian triangulation arc

The astronomic observations on the Arc in the Sudan were made by the Sudan Survey Department, and in Southern Rhodesia and the Union of South Africa by the Trigonometrical Survey in Mowbray. A number of additional Laplace stations have been established since 1954.

During the period 1960-1962 the Sudan Survey Department observed a triangulation chain starting from Quleit base in the Arc of the 30th Meridian and extending westward between the 13th and 14th Parallel to the border of Chad (Kordofan-Darfur Triangulation). The Sudan Survey Department was assisted by the U.S. Corps of Engineers and the Agency for International Development in the measurement of four base lines by supplying an AGA Geodimeter with all accessory equipment and a party of three operators. In addition, five Laplace stations were established along this chain with Wild T-4 and T-3 instruments of the Sudan Survey Department. The accessory equipment (radio, chronograph, chronometer and amplifier) was supplied by the U.S. Corps of Engineers. For the purpose of establishing a geoidal profile, nine 2nd-order astronomic positions were observed along the arc Also, gravity measurements were made at approximately 20 stations using a LaCoste-Romberg gravity meter.

Over the past 100 years much fine survey work has been completed in Africa. A framework of good interconnected basic control covers about one-fourth of the continent. In the remaining threefourths there are many valuable local surveys, but the untouched areas are still vast. The goal to be attained is, of course, a unified continental network that provides for mapping, for the accurate delineation and description of boundaries, and for the necessary surveys for national development of public works and private enterprise. This can be attained by years of intense effort on purely national lines with results commensurate with the resources that can be applied to it. But it could be attained much more efficiently and economically by well planned efforts over large areas, perhaps of many nations. Great benefits would result from the pooling of material resources and the full utilization of these resources throughout the changing work seasons. A study of the ways and means of preparing and implementing a plan of this scope would seem to be of the intense concerns of this conference.

Aerial photography, photogrammetry and topographical mapping

NOTE ON THE METHODS USED BY FRANCE IN PRODUCING THE MAP OF THE COUNTRIES OF BLACK AFRICA IN PROCESS OF DEVELOPMENT[1]

Institut géographique national, Paris

The purpose of this document is to describe first the cartographical difficulties which confronted the French National Geographical Institute when in 1945 it was entrusted with the task of making the general map of the French-speaking Black African States, and then the methods and means which, in the light of experience, appeared to it most suitable for finding an economical and expeditions solution.

This statement will lead to conclusions that will doubtless be of interest to the developing African States.

First, mention should be made of the essential factors of these difficulties which were characterized by:

1. *The immense size of the territories to be mapped:*

E.g., French West Africa—Togo . . .	4,675,000 km²
E.g., French Equatorial Africa—Cameroon	2,900,000 km²
TOTAL	7,575,000 km²

or about 14 times the surface of France.

2. *Exceptional mapping conditions:* first, because of the scarcity of means of communication and supply centres, then also because of the scarcity of manpower, the unwillingness of workers to leave the villages, the difficulty of travelling through dense, almost impenetrable forests and across the dunes of the Saharan borders, the considerable distances from repair or supply points, and, finally, because of exceptional climatic conditions which restricted field work to short periods of the year, and the like.

3. *A non-existent infrastructure:* cartographic equipment was limited to some fixed areas of Senegal, Guinea, Mali and Cameroun. With a few exceptions, it was ill-assorted and unsuitable for use in modern map-making. Therefore, nearly all the equipment had to be replaced.

4. *Imperious and very urgent needs:* since the necessity of developing these territories was obvious and since the preparation and execution of coherent development plans dependent largely on the establishment of reliable cartographic documents that would supply a thorough knowledge of the country.

The wide range of the difficulties to be solved was, therefore, exceptional and the means the beneficiaries could supply were practically nil; further there were no autochthonous technicians.

It was obvious that because of their cost price and the time it takes to put them into operation classical survey methods were impracticable. New methods had, therefore, to be found.

The French National Geographical Institute thought that the most rational and most economical way of meeting these difficulties would be:

(*a*) To provide, methodically and as quickly as possible,

[1] The original text of this paper, submitted by France, under the title "Note sur les méthodes employées par la France pour l'établissement de la carte des pays d'Afrique Noire en voie de développement", appeared in French as document E/CN.14/CART/8.

all territories with a vertical and stereoscopic aerial coverages on a scale of 1:50,000. Definitive documents, therefore, which would give a faithful image of the land and of themselves, constitute for the technicians and research workers, an incomparable instrument of work while awaiting the issue of maps;

(*b*) To provide at the same time, infrastructure essential to base cartography; infrastructure consisting for the horizontal control of an astronomical control net, for the vertical control of a geometric precision levelling net, soundly laid out and marked;

(*c*) To use this infrastructure as a base for a general 1:200,000 map and, locally, according to the development needs of certain parts of these territories, a more elaborate map on a scale of 1:50,000. Contrary to the infrastructure, which it was desired, from the start, should be definitive, this map would be prepared and published in successive phases from the blank "horizontal control" to the final map in 5 or 6 colours.

It seems useful to specify certain characteristics of this work.

(1) The strict rules which the French National Geographical Institute imposed upon itself for the carrying out the aerial coverage (overlappings, camera tilt, rigidity of plates) make it possible to derive therefrom, in the workshop, multiple cartographic advantages. These photographs serve not only for the interpretation and establishment of aerophotographic mosaics or photoplans but also, and above all, for carrying out horizontal and vertical aerial triangulations and plottings.

(2) The geometric precision levelling net serves both for the detailed vertical fixations necessary for the exact representation of the relief and for specialized studies on hydraulics, ways of communication, urbanism. Meteorological stations and aerodromes are attached to it.

(3) In this first phase of the work, the French National Geographical Institute proceeded to lay out astronomical control nets at intervals of about 50 km. marked and identified on the aerial photographs. This method was preferred to the classic triangulation methods because of its incomparable flexibility, its convenience, its rapidity of execution and operation, and its low-cost price. The absolute precision of these fixations, account being taken of the material and methods used, is about ± 50 m., which appears quite adequate for a 1:200,000 map. The geodetic networks are at present reserved for very restricted areas which it is desired to map on a large scale.

(4) The base map which is prepared by the National Geographical Institute relies at all stages of its preparation on the above-mentioned aerial photographs and infrastructure.

The planimetric net is achieved by photographic triangulation-graphical or calculated—resting on the astronomical points.

The detailed vertical control is attached to the precision levelling. It is obtained, depending on the case, either directly by differential measurements of barometric pressure, or by registration of Airborne Profiles or, finally, by aerial traversing.

These techniques are well known and it seems useless to explain them in detail.

The methods employed for the establishment in the proper sense of the word of the 1:200,000 map vary according to the relief, the nature of the vegetable cover and the possibilities of access.

(*a*) *In the flat regions of easy access.* Whatever the vegetable cover, in the workshop aerial photographs are interpreted, under a stereoscope, and plotted. Then, in the field, the altimetry and place names of the topographical base thus obtained are inserted. The operator determines on the barometer the altitude of the land points necessary for contouring and collects place names, information concerning the traffic possibilities of the roads, the administrative boundaries, water points.

After which the map is edited and printed.

(*b*) *In the moderately uneven regions three cases have to be considered:*

(1) *Vegetation not very dense and easily accessible.* Same process as above but the operator determines by zenithal sight-lines a denser levelling network which enables him to guide the contours under the stereoscope efficiently.

(2) *Vegetation not very dense but access very difficult.*

The order of operations is as follows:

Registration of Airborne Profiles in the overlap areas of the photographic strip;

Attachment of these profiles, planimetric and toponymic "special checking";

Radial-line slotted template triangulation;

Plotting;

Editing and printing.

(3) *Very thick vegetation of easy or difficult access.*

Fined down barometric stereoscopic ground control, or airborne profile squaring, at the rate of an itinerary approximately every 40 km. At the same time a planimetric and toponymic special check is made;

Aerial traversing;

Plotting;

Editing and printing.

(*c*) *Very uneven regions.* Same procedure as for (*b*) (3).

Methods used for the production of 1:50,000 maps

They are always the same, depending on vegetable cover, as those described under (*b*) (2) and (*b*) (3) above, but with this difference that plotting is always carried out with precision cameras.

Conclusions

The methods described above have been thought out and developed in the offices of the National Geographical Institute in Paris.

Their application has made it possible to reduce considerably the volume of ground work and in this way to mitigate to a great extent the "exceptional mapping conditions" mentioned above which could not, in many cases, have been overcome by classical survey methods.

The following are the results obtained by the National Geographical Institute in 13 campaigns:

Vertical aerial coverage	7,500,000 km²
Astronomical control work: 6,520,000 km² or approximately	4,900 fixations
Precision levelling: approximately km . . .	67,000

Mapping at 1:200,000 on nearly 5,500,000 km².

This enumeration shows the advantages of the solution adopted. Without claiming that it can be used universally it is probable that because of its effectiveness, its cost price and the relatively modest means used, it is perfectly adapted to most of the difficult situations in the development of emerging countries.

AERIAL PHOTOGRAPHS AND INTERIM CARTOGRAPHY ON A 1:1,000,000 SCALE[1]

By H. de Corbiac, Ingénieur en chef géographe, Institut géographique national

The question of maps on a 1:1,000,000 scale

The normal process of compiling maps on a 1:1,000,000 scale consists essentially in making an appropriate generalization of the most detailed maps, generally called "base maps", which have been prepared in their turn directly from aerial photographs.

At present, for populated areas, or areas presenting features of particular interest, the base map has generally been completed. It is prepared on scales varying between 1:20,000 and 1:200,000 according to the importance of the area. The production of a map on a 1:1,000,000 scale is then very simple.

In desert areas, on the other hand, the base map produced from photographs is generally rudimentary. In the Sahara, until very recent years, that was certainly the case.

In order to compile a new map on the 1:1,000,000 scale of the ICAO type, it would in most cases have been necessary to use as a base the only existing document, which was the reconnaissance map known as "Croquis de l'Afrique au 1/1 M" ("Sketch-map of Africa on a 1:1,000,000 scale"). This map, the preparation of which was geared to the camel's gait, was particularly deserving of praise when the extent of the difficulties, the special conditions of the survey and the incredible inadequacy of the means employed are considered.

This map was still very incomplete when the general photographic coverage of these territories was carried out, beginning in 1950 and at an extremely rapid tempo.

The following paradoxical situation then confronted us: although complete vertical stereoscopic photographic coverage of these areas on a 1:50,000 scale was available, it was impossible to derive any advantage from this for the "Croquis de l'Afrique au 1/1 M", and consequently for the ICAO map, without preparing beforehand, for each of the 15 sheets on a 1:1,000,000 scale:

Either 384 sheets on a 1:50,000 scale;

Or 94 sheets on a 1:100,000 scale;

Or 24 sheets on a 1:200,000 scale;

which was utterly impracticable within acceptable time-limits, taking into account the programmes already in progress. At present, despite the particularly ample resources deployed in the Sahara, the Institut geographique national is only undertaking the preparation of about 20 map-sheets on a 1:200,000 scale, that is to say less than one sheet on a 1:1,000,000 scale each year.

Solution adopted

In these circumstances, the most neglected areas run the risk of waiting for a long time still before the regular edition of the map is issued. That is the case, more or less generally, for Africa between the 16th and 26th parallels.

It has thus been decided to produce an "interim" edition by direct utilization on a 1:1,000,000 scale of photographic coverage.

An extremely rapid interpretation of photographs can lead to certain mistakes, but it nevertheless permits the positioning of all the most important details with a precision and an "expressiveness", that satisfy all the essential requirements of the user of a map on this scale. It must be borne in mind:

(1) That a provisional remaking of this kind is all the more advantageous in that it is completed more rapidly, from which follows the advantage in direct editing on a 1:1,000,000 scale, omitting any intermediate stage;

(2) That the anxiety to achieve rapidity leads to no unduly rigorous strictness being exercised in the positioning of the drawing, as in any case it is necessary to content oneself with an astronomic control that is sometimes very approximate, and as the drawing of details on the 12,000 photographs for the sheet must, of necessity, be scaled down "freehand" in a ratio of 20 to 1, by a simple stroke of the pencil;

(3) That the primary preoccupation must be that of fidelity to forms, so as to permit identification on the map of the details which are apparent on the photograph, and vice versa. For a map of this description, in addition to the services that it can afford to aerial navigation, must also serve as an informative index for all those prospectors who would today scarcely contemplate doing without photographs and often, indeed, have nothing else.

In order to produce this "interim cartography", it is sufficient for total vertical stereoscopic photographic

[1] The original text of this paper, submitted by France, under the title "Photographies aériennes et cartographie d'attente au 1/1 M", appeared in French as document E/CN.14/CART/16.

coverage to be available, and likewise astronomic points spaced out at intervals of 50 to 500 km. and identified on photographs (an astronomic point every 100 km. constitutes a very favourable density).

Method of editing

Positioning of the photographs on the field-sheet

A general index of the photographic coverage must be set up, by utilizing the astronomic points identified on the photographs, and by "positioning" the photographic strip taking these points as reference. In order to do this, a framework of layouts of photographs (shown tinted in figure 1) is prepared between the astronomic points, according to meridians or parallels. Adjustment is made to the optimum extent in these layouts when transferring them on to the field-sheet (on a 1:1,000,000 scale). The intervals between two successive photographs (figure 1) are deemed to be constant in one strip.

The drawing of the surface covered by each photograph (1 out of every 2 is drawn) is facilitated by the use of a window pierced in a transparent mount and calibrated in such a way as to permit guiding the delineation of a square representing, to scale, the surface of the map corresponding to a photograph, for example, a square having sides of 9 mm. for the Sahara, as the photographs have a format of 18 × 18 and a scale of 1:50,000.

In the case of an area that is poor in astronomic points (figure 2), it is necessary to cover long distances in linking up the partial layouts end to end; the intersections of meridian layouts and parallel layouts then form nodal points which serve as compensation in the layouts. When it is necessary to undertake the setting up of layouts that cross several flights, it seems possible, in the case of longitudinal strips placed end to end, to take into account the relative scales of these strips, a study of the areas of overlap permitting all the desired comparisons to be made. In the case of transversal layouts, a calculation of this kind—which would have to be repeated for each photograph—would take a very long time and would probably yield deceptive results; it is thus necessary to be satisfied with applying over-all adjustments, assuming that all photographs are on the same scale.

In the case of an astronomic preparation made after photographs have been taken, the matter is very much simplified, as the points are perfectly identified and favourably situated.

The possibility might occur to some of taking into account the angles of deviation of the photographs or small changes in the direction of flight, but experience has proved that it is not possible thereby to avoid unforeseen divergences appearing. Thus, photographs are considered as being uniformly aimed, except in certain extreme cases. Any necessary adjustments are introduced at the moment of drawing, and are in any case dictated by the necessity of forming a proper join with adjacent strips.

When the framework is in position, the indices are completed without difficulty, with the aid of interpolation grids set up for the differing tempo employed in photographing (figure 1). The index thus obtained is printed on the reverse of the map.

Drawing. In view of the quantity of photographs to be examined, organization is of overriding importance. The photographs are set in relation to the field-sheet. All the manipulations that follow are carried out in the same way that the pages of a book are turned, as each photograph is used several times in the course of the various operations that are necessary:

(1) Setting up of the adjusted index, delineated in pencil directly on the field-sheet;

(2) Summary stereoscopic roughing out of variations in the terrain, which are difficult to identify on isolated photographs;

(3) Provisional drawing of the positioning, strip by strip, transferring the details of the photograph to the interior of the transparent window, which has been placed beforehand in the desired position on the field-sheet, with the aid of the plotting of the index;

(4) The final drawing joined strip by strip, with the fair copy made in ink;

(5) Search for and transfer of details shown on the old map, such as: wells, tracks, villages, etc. Positioning of the toponymy.

If the scaling-down by 20 to 1 requires a certain degree of training, it should nevertheless be noted that a generalization of this sort, however bold it may be, has the fundamental advantage over the usual succession of cartographic generalizations that it is made "true to nature". In the normal process, the "character" of the ground risks disappearing little by little, whereas in this case the editor can always add at the last moment accents suggested by the direct sight of any abrupt features to be represented.

This is all the more important because, with the intensive utilization of photographs, a new type of medium-scale map has appeared. This type of map is characterized by an excessive proliferation of secondary details, which detracts from its clarity and does not facilitate later generalizations, when these are carried out by draughtsmen who are deprived of the opportunity of seeing the model. Representations that are often confused, and sometimes even of wretched quality, result from these circumstances, to such an extent that it has proved necessary to revert to the photographs in order to improve the generalization on a 1:1,000,000 scale of certain productions that were, however, of the regular 1:200,000 scale.

Levelling. The data involved in levelling remains the same as in documents that have to be remade. The contours of level necessary for plotting the limits of the hypsometric tints of the ICAO map are simply adapted to the new planimetry, or else made to correspond with the new vertical data established.

Variations in the terrain are indicated by local scribing of figurative contours obtained by direct roughing out from the photographs. These figurative contours may, with advantage, be made to stand out by an appropriate relief shading. This is the only way to make apparent major variations in the terrain.

The parallax bar provides valuable indications for measuring the relative contours between two points that are close together, like the top and the foot of a cliff

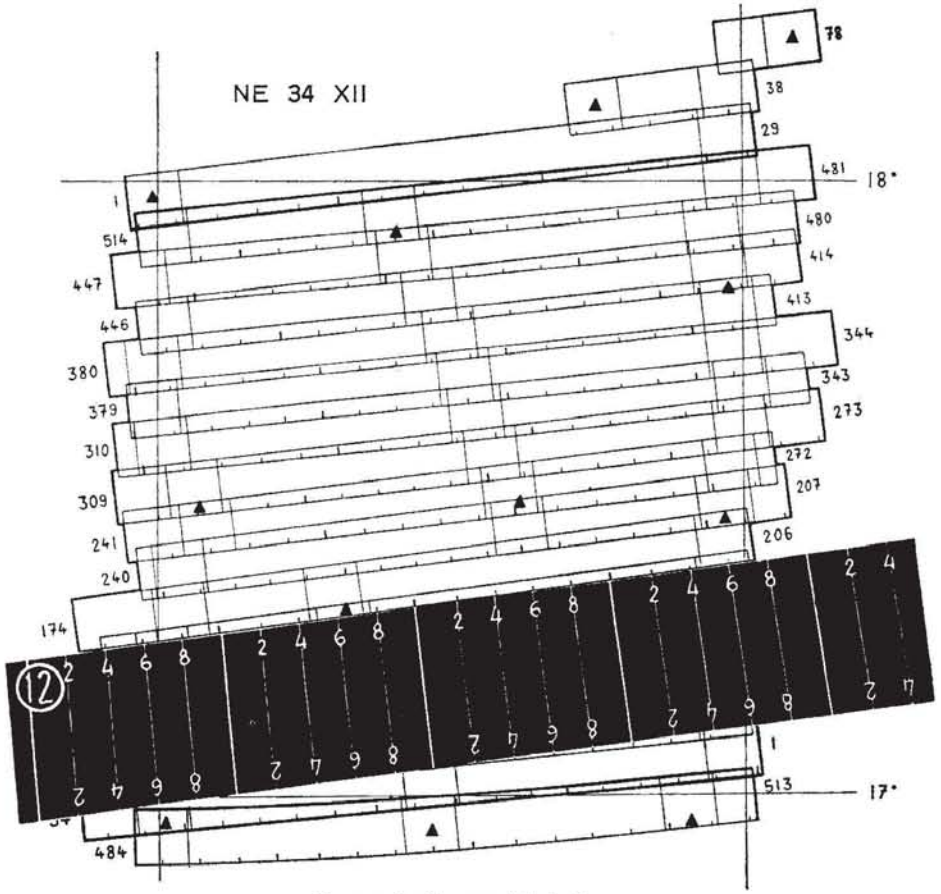


FIGURE 1: *Set up of the index*

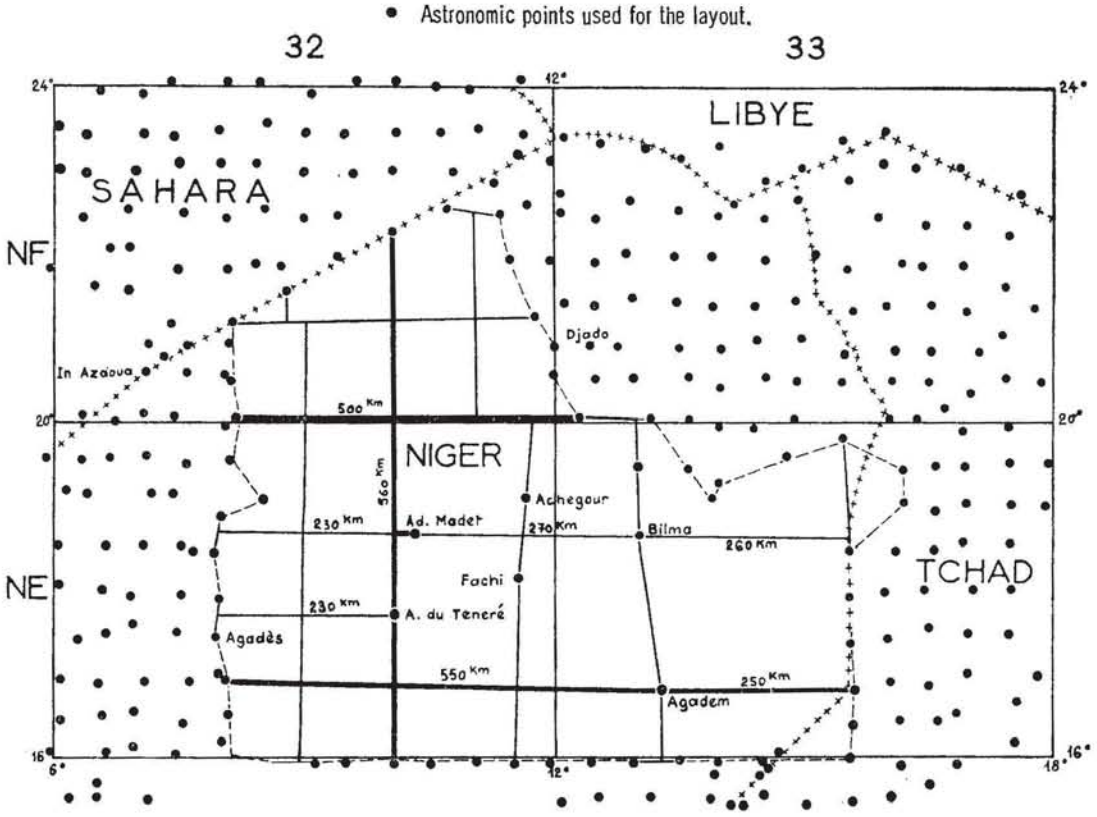


FIGURE: 2 *Layout of meridian and parallel photographic strips of a region for which astronomic points are pooriy distributed*

or an escarpment. The value of the base used for taking photographs, which is necessary for the calculation of contours, can be measured on the grid which has been used for the layout of the strip in question, and the scale can be deduced from the relationship between the length of a photographic strip and the corresponding length adopted on the field-sheet. In the case of this map on a 1:1,000,000 scale, however, it is only necessary to determine the magnitude of the contours observed, and simply to adopt a formula corresponding with the average conditions attendant on photographing (format, focal distance, scale, overlap). The contour between two points will be evaluated in accordance with the difference between the parallaxes.

In the case of the great majority of photographs taken by the IGN in the Sahara (format 19 × 19—focal distance, 125 mm.—scale 1:50,000—overlap, 60 per cent), the contour in metres between two points is virtually equal to 6/7ths of the difference of parallax read in 1/100ths of a millimetre between these two points.

Unidentified details. When it has been impossible to identify on the photographs details shown on the old map, they cannot for that reason be omitted. Their positioning, however, in relation to a background that is now identifiable is uncertain. It is, therefore, expedient to show them in their probable position by a special sign meaning: "horizontal position uncertain".

Productivity

A qualified and trained operator can compile in six months a sheet on a 1:1,000,000 scale, of the ICAO type, of average difficulty (or nearly 300,000 sq. km.).

It may be noted that utilization of the photographic coverage of the Sahara has been greatly facilitated by the remarkable regularity of the photographs taken by the Group of squadrons of the IGN.

Conclusion

Maps prepared in this manner constitute a faithful homogeneous, and very expressive document, for aviation in particular. The work can be carried out independently of the normal procedures of map compilation. It allows us to await with less impatience the production of the definitive maps in stages. Two samples of maps were distributed to participants.

NOTE ON THE METHOD USED BY THE INSTITUT GEOGRAPHIQUE NATIONAL IN COMPILING THE MAP ON THE SAHARAN REGIONS ON THE SCALE 1:200,000[1]

The preparation of maps by aerial stereophotogrammetry, a method now used almost exclusively throughout the world on all so-called "topographical" scales, necessitates knowledge of the co-ordinates and altitudes of a certain number of landmarks identifiable on the photographs. At the plotting stage these marks are necessary because the position and bearing parameters of the plates cannot be determined with the desired degree of precision at the time the photographs are taken.

Chronologically, the first method employed consists in entirely determining this plotting control by ground operations relying on dense, precise and homogeneous geodetic and levelling networks. This is still the only practicable method for regular surveys on so-called medium or large survey scales, from 1:1,000 to 1:20,000.

Although clumsy and costly this method is still tolerable in countries with a high population density, where the communications network is dense, where there are several road-posts and the approach is easy. The length and cost of ground operations become prohibitive in sparsely populated, desert or semi-desert regions, where the map scale is smaller (1:50,000, 1:100,000 or 1:200,000), and where, in consequence, the desired vertical precision is lower.

An effort was therefore made to replace ground operations by measuring operations on photographs and by computations, by means of which a large proportion of the ground operations can be dispensed with, the latter being reduced to determination of a limited number of points in position or in altitude. This method, which is very generally used, no matter what the nature of the ground, its contours, or its vegetative cover, is known as aerial traversing. It has been used for some fifteen years with various application procedures in accordance with constant and well defined general principles.

The appearance of large modern electronic computers, which enable internal (liaisons between plates within the same block) or external (introduction of data from auxiliary devices, such as the statoscope, vertical recorders, etc.) adjustment operations, formerly approximatively effected by graphic or mechanical means, to be replaced by stricter computations, has in the last few years, led to new developments in the aerial traversing method and to its being re-oriented.

This aerial traversing does, however, include a certain number of successive operations—from the preliminary operations of the selection and pricking of points to the final stage of definitive computations and adjustments—which require time, highly specialized staff and the operation of rare and costly equipment: first order plotting devices, high precision stereocomparators and very powerful electronic computers.

When, therefore, in 1958 the IGN had, by systematically surveying approximately 200,000 square kilometres annually, to establish a 1:200,000 map of the Saharan regions it sought a method which would make it possible to determine the necessary plotting control without recourse to aerial traversing. For this purpose it used

[1] The original text of this paper, submitted by France, under the title "Note sur la méthode employée par l'Institut géographique national pour le levé de la carte au 1:200,000 des régions sahariennes," appeared in French as document E/CN.14/CART/18.

a device which had appeared on the market a few years earlier, the airborne profiles recorder (APR).

A. The APR principle

Let us recall briefly that the APR consists of an aerial, directed vertically, which transmits a narrow beam of electromagnetic rays. These are reflected by the ground and captured by the aircraft carrying the device, the latter measuring the time that elapses between the transmission of one wave and the reception of the reflected wave. This results in a continuous graphic recording of the uncorrected air-ground distance, which gives a profile of the terrain on a certain scale. Variations in the aircraft's altitude are detected by a very sensitive hypsometer whose indications combine with the echo reception to furnish a corrected profile (red profile) which is the ground profile as related to an isobaric surface. If the absolute altitudes of two ground points on the profile are known, the tilt in relation to the level surfaces of the isobaric surfaces, presumed to be parallel, can be deduced (which is legitimate in view of the slight variations in the height of the aircraft); the profile may then be adapted to bring it into line with a level surface and, on the basis of the known altitude points, the absolute altitudes of all points of the profile may be determined.

In addition, the APR contains a small camera the axis of which is set parallel to the transmitting aerial and the shutter releases of which are recorded on the registering ribbon of the profiles, in this way identifying on the profile each centre of the small 24 × 36 mm. photographs taken by the camera.

B. Method of plotting control determination used for the 1:200,000 map of the Sahara

I. *Horizontal control.* Planimetric control is achieved by the now classical slotted template triangulation method. This control is based on a small number of astronomical points (approximately 50 to 60 km. between neighbouring points). If the large mountain masses (Hoggar, Tibesti) are discounted, the topography and tectonics of the Sahara are even enough for deflections from the vertical to be only slight. The relative errors between neighbouring points, resulting from their own errors, and differences in deflection from the vertical are spread each time over a distance of from 50 to 60 km. and correspond to scale variations which are hardly perceptible on the scale of the map.

II. *Vertical control.* The method used for the map of the Saharan regions is original because the profiles are not recorded while photographing along the axes of photographic strips but during a second flight, following routes which are projected on the ground in the overlapping area common to two contiguous strips of photographs. These "longitudinal" profiles are completed by "transversal" profiles, some of which will be found in the overlap area between neighbouring photographic missions, the overlap area being chosen in a favourable region. Other transversal profiles will be chosen more arbitrarily in such a way that each longitudinal profile will be cut again by at least three transversal profiles. In fact, one transversal profile every 100 km. may be sufficient.

The flying height chosen for the recording of profiles is such that the scale of small 24 × 36 mm. photographs is very close to that of the stereoscopic coverage photographs used for plotting. Since the normal focus of the complete APR camera apparatus is 27 mm., if the photographic coverage has been effected with a 125 mm. focus chamber at 65,000°, i.e. at a flying height of 8,100 m., profile recording will take place at a flying height of approximately 1,850 m.

C. Ground work

Astronomical points will be fixed by means of the now classical procedures of position astronomy. The position of these points is not rigidly laid down; the distance between neighbouring points may vary quite considerably. In the case of the *Great Western ERG*, certain points provided in the initial plan had to be abandoned because the terrain was difficult; the average distance of 50 km. between neighbouring points was therefore increased to approximately 100 km. with no special difficulties as a consequence. On the circumference of the block, points are selected in such a way that the slotted template triangulation is not extrapolated.

In so far as the altimetric network of recorded profiles is concerned, the longitudinal and transversal profiles together constitute an aggregate which can be adjusted intrinsically. As a rule then, it is sufficient in order to determine the absolute figures of the aggregate to have four known points in absolute altitude to the four points of the block.

In view of the precision obtained from recorded profiles, the barometric determination of absolute altitudes must *a priori* be excluded. A precision levelling will be necessary to link up with the APR network. The APR profiles will be extended until they cut a levelled route again, and the survey "block" will then be constituted as a dependent variable of the levelling network.

The ground work will consist, therefore,—in the case of each point selected strictly on a profile in proximity to its intersection with the levelled route—in determining the altitude of the point from the nearest levelling mark, situated in the worst case, at a distance of 3 to 4 km. away.

D. Office work

The photographs are prepared by pricking and numbering on them the points of the horizontal control to be determined by slotted template triangulation. Since the points must be precisely defined horizontally they will very often be different from the adaptable vertical points which should preferably be selected in flat areas, even if their horizontal localization is badly defined.

In the case of the map of the Sahara, which is made from photographs on scales between 1:65,000 and 1:90,000, the assembling of the slotted template triangulation is effected on a scale of 1:100,000, the transfer of points on to 1:200,000 maps being carried out by means of a pantograph.

With respect to altimetry, the analysis of profiles will involve a certain number of operations: first, the smoothing of the registration curve, a very deeply serrated drawing of which the average drawing must be taken. The centre of each of the small photographs is then transferred on to the photographs of the cartographic coverage. The approximate equality of the scale of the two documents makes it possible to observe, stereoscopically, a small 24×36 mm. photograph twinned with a 18×18 cm. or 23×23 cm. photograph. This transfer by stereoscopic observation is indispensable, for the point to be transferred is not always made material by a clear detail.

The points necessary to the absolute orientation of each couple, selected obligatorily on the line defined by the recorded profile, and on a piece of flat or gently sloping ground, are then transferred on to the axis of the abscissae of the recording sheet of profiles, by simple proportionality between the distances taken on the photograph between the centres of the small photographs and the corresponding distances on the recording graph.

E. Adjustment of the network of recorded profiles

A specific adjustment of this network must first be made, an adjustment which is possible without any absolute altitude being known. It is thus absolutely independent of ground observations; it can be made *a priori* and when the results of the bridgings on the ground are received in the computer workshop the absolute elevations can be determined very quickly.

If the network of all the nodal points constituted by an intersection of the longitudinal and transversal profiles is considered, and if, starting from a block angle with an arbitrary altitude, the altitudes obtained for each nodal point by following two different routes are determined, two different altitudes will be obtained. If the altitude "constants" corresponding to each profile are made to intervene as unknowns and if the equality of altitudes for the various courses is written on each nodal point, a number of linear equations superior to the number of unknowns will be obtained, and these will be treated by the least squares, in this case, a particularly simple operation because the not nil coefficients are equal to one.

Once inter-profile coherence is ensured these altitudes of arbitrary origin will have to be transformed into true altitudes. If the level surfaces coincides with the isobaric surfaces a single known altitude would be sufficient to mark the dimensions of all the profiles. This coincidence has not, however, occurred; there is moreover a theoretical formula giving the slope of isobaric surfaces, as compared with the level surfaces, in terms of the angle of drift of the aircraft, the latitude and the earth's rotation, but this formula is based on certain hypotheses which have not been strictly checked. It appears safer, therefore, to determine the true altitude of some selected points on the circumference of the block, by linking up with levelling marks. The differences between true altitudes and altitudes obtained after internal adjustment should vary linearly; they indicate the slope of the reference isobaric surface as compared with the level surfaces. The profiles could then be "adapted" to the points of known altitude; if there are too many known points the adaptations could be made on average values derived from groups of neighbouring points. The residues on the known points after this adaptation will make it possible to define the precision to be expected of the method.

The determination of the altitude of points necessary to plotting, transferred, as has been seen, on to the recording graph of the profiles, merely requires simple measurements of ordinates.

F. Limitations of the method

The width of the cone of waves transmitted by the APR is not negligible and cuts out a circular section on the ground; if, however, at a given moment the axis of the transmitting aerial is not strictly vertical, this section will in reality be slightly elliptical. It might be said that the recorded echo is a sort of mean of echos relating to the various points of the section of the beam and that this mean corresponds at a given moment to the plumb point of the aerial, and therefore, at the moment when the shutter of the small camera is released, to the centre of the small 24×36 mm. plate. On broken ground, at a place where the slope changes, the echo will no longer refer to the plumb point of the aerial but to a point the position of which has been shifted and which is moreover extremely difficult to define. In this case therefore there will be an altimetric error in the plumb point of the small photographs which will be difficult to calculate but which will rapidly become unacceptable.

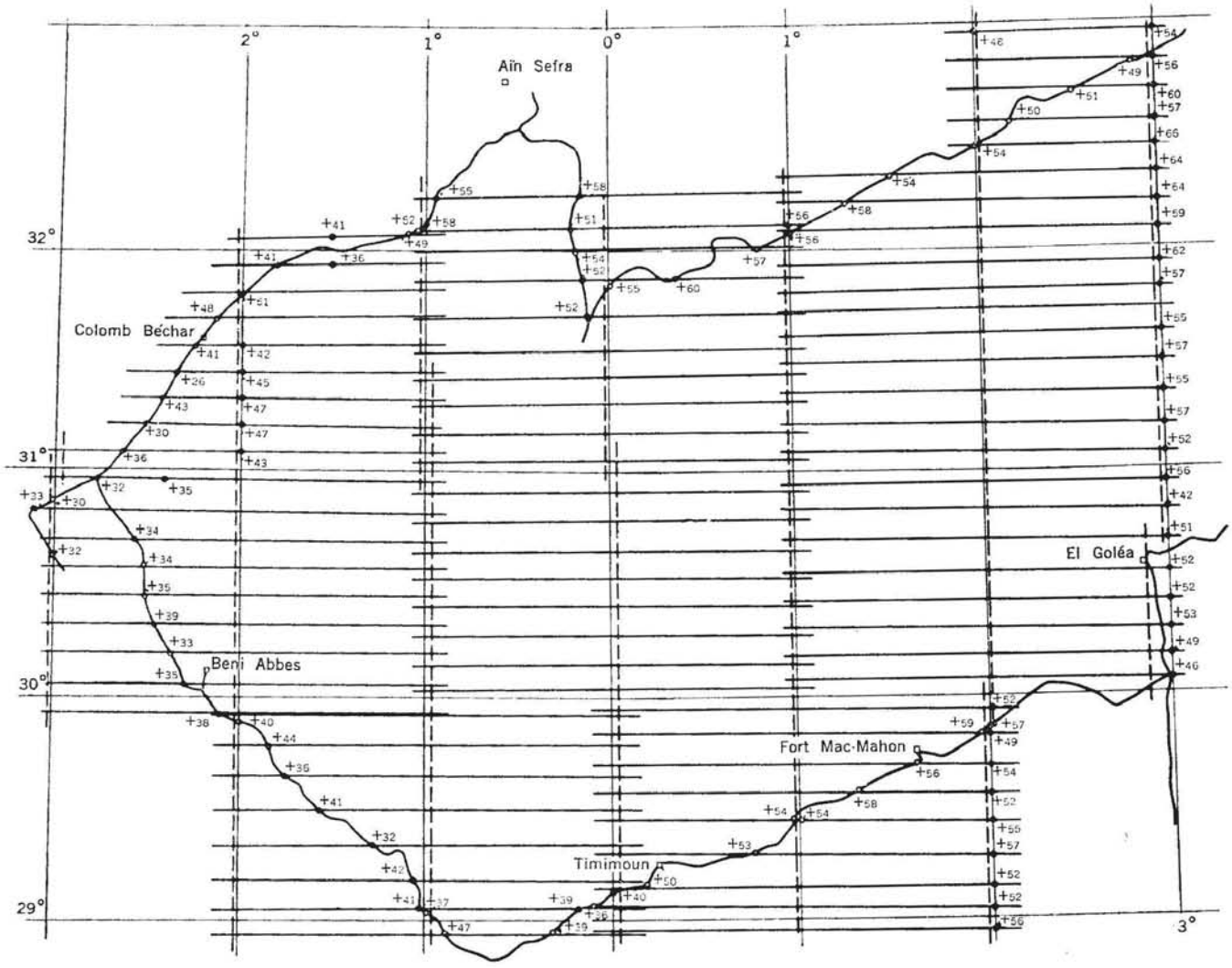
The important thing, therefore, is not that the ground should be even but that it should consist of sufficiently extensive areas, which are flat or with a slope, regular not too steep, to enable the recording to be stabilized and where the vertical control points necessary to plotting may be selected. In the Sahara, for example, even a broken contour is frequently of the tabular type and the method can be employed without great inconvenience. On the other hand, a classical topographic terrain, where the slopes change frequently, cannot be treated by this method without unacceptable errors. An isolated undulation in the ground, even if very pronounced, will not lead to rejection of the method; the photographs covering this isolated undulation should then be treated by spatial aerial triangulation. Subject to the above-mentioned reservations with respect to relief, the Saharan lands and barren lands generally lacking in vegetation lend themselves particularly well to the application of the APR method.

G. The advantages of the method

The most obvious advantage of the method is that it enables vertical plotting control to be determined quickly, without complicated calculations and with extremely reduced ground operations.

Its originality lies in the determination of absolute altitudes in comparison with the zero level surface, from relative broken stretches to an isobaric reference surface, in principle variable with time in form and in position.

The principle adopted consists in re-establishing the homogeneity of longitudinal profiles with the assistance of transversal profile for, in the case of a large block, the longitudinal profiles cannot all be recorded on the same day and atmospheric conditions may vary from one day to another and even during the course of one and the same day. The coherence of results obtained by the simple adjustment method described above, however, and the smallness of residues show that in Saharan regions, in the proximity of the altitude selected for profile recordings, the atmospherics are sufficiently stable for the isobaric surfaces to be considered as having constant slopes and curvatures and varying simply by a vertical translation.



Erg Occidental

H. Results obtained

This method has been used for several years for the annual successive 1:200,000 survey strips of the map of the Sahara.

The attached diagram relates to a particularly important block, that of the Great Western Erg, difficult travelling terrain, where the density of astronomic points initially planned has, as has been seen above, to be reduced.

This block which in surface covers 17 sheets on the approximate scale 1:200,000 (185,000 sq. km.) is based, to the north, west and south on a precision levelling transom and to the east on reference points determined by the APR during a previous survey of a neighbouring block. It is furthermore linked with various survey (photogrammetric on scale 1:100,000 to the north, and topographic by a plane-table instrument on scale 1:200,000 to the west).

The diagram shows the gap between the provisional elevations obtained after internal adjustment (defined to the nearest constant to 50 m.) and the true elevations derived from ground observations or bridgings, the value of the former being in general much more precise.

After a definitive adjustment including particularly an east-west adaptation, the average value of the residues is from 3 to 4 m. and the number of reference points on the ground is very largely superfluous; now all these points have been transferred on to the diagram, even

those the determination of which is unfavourable for the APR, and there is a certain number of these, particularly in the mountainous Colomb-Bechar region to the west of the block; logically, these points should have been omitted from the results. It is noted therefore that the homogeneity of the whole is very satisfactory and very suitable for a 1:200,000 survey.

I. Use of super wide-angle lens cameras

The minimum scale of photographs is limited by the ceiling of the aircraft used for photographing and the focus used. With wide-angle lens cameras this minimum scale is approximately 1:65,000, corresponding to a flying height above ground of approximately 8,000 m. The use of super wide-angle film cameras has made possible, for a same flying height, photographying on an approximate scale of 1:90,000.

The diminution in scale on the one hand and the larger plate size on the other (23 × 23 instead of 18 × 18) permit a considerable gain in the number of plates covering a given surface. For a 1:200,000 sheet (1° × 1°) the number of couples is brought down on an average to 280 per hundred. Despite the size of the field of the photograph, plotting is possible on double sliding front plotting devices available to the Institut géographique national, in particular on type D Poivilliers stereographs. The main plotting distance selected is amplified in relation to the main distance of photographs in such a way as to remain in the mechanic latitude of the apparatus.

The use of the super wide-angle lens camera in favourable regions has made possible a substantial saving in photographs (number of strips diminished in the proportion of 16 to 10), profile recordings (number of longitudinal profiles diminished in the same proportion), and the later operations of profile analysis, altitude determination, and the erection of couples on plotting devices, since fewer are required for a given surface.

Conclusion

Since 1958 this method has been used in the 1:200,000 survey of more than 700,000 km² of the Saharan regions.

Subject to conditions which must be carried out for judicious use, it is an extremely effective and quick method the main advantages of which are ease of analysis and altitude calculation operations and the very small number of base altimetric points to be determined on the ground.

The blocks to be treated in this manner cannot be selected arbitrarily; their form is determined essentially by the density and positioning of precision levelling transoms which are necessary but which, in any event, constitute an indispensable piece of equipment for all the various studies concerning the development of the territory.

NOTE BY THE INSTITUT GEOGRAPHIQUE NATIONAL ON THE USE OF APR (AIR PROFILE RECORDER) FLIGHTS ABOVE THE EQUATORIAL FOREST[1]

For five years the Institut géographique national (IGN) has systematically applied the APR in compiling regular small-scale maps of desert, more or less flat regions. It is known that the procedure permits direct determination of the over-all vertical control necessary for plotting.

The IGN has tried to extend the application of the method in equatorial regions where the thickness of the vegetation, difficulties of access and the virtual impossibility of finding on the ground "ground points" identifiable on the photographs practically preclude the adoption of the classical stereoscopic ground control procedures.

To this end, the IGN has recently made an experiment in the Franceville (Gabon) region, which is already covered by a 1:50,000 map.

The following are the conditions under which this experiment was undertaken: the comparative study of the profiles was made following the simultaneous taking of photographs on APR plates, at a height of 1,700 to 1,800 m. and of stereoscopic photos on 19 × 19 cm. film, with a focal distance of 125 millimetres.

The study consisted, successively, of:

(*a*) Selection of a certain number of pairs from among the most characteristic in view of the vegetation cover, going progressively from almost bare ground with some forest galleries, to land entirely covered by the great forest;

(*b*) Identification of the photographed strip on the 1:50,000 map and the scribing of the axis of flight;

(*c*) Construction of a profile of the land following the contours (contour-interval 20 m.) of the 1:50,000 map. It should be noted that this profile allows serious doubts to remain as regards wooded areas, because of the differences in the heights of trees;

(*d*) Installation of all the pairs chosen on a type D Poivilliers plotting device and the scribing of the profile of the vegetation cover by successive points along the axis followed by the aircraft;

(*e*) Reduction of the profile recorded to the same scale.

With these various elements it was possible, by causing the three scribings to coincide everywhere where the land was bare, to compare the recorded profile, the ground profile as deduced from the map and the profile, obtained from plotting, of the top of the vegetation.

The results obtained suggest the following remarks:

(1) On bare ground, the recorded ground profile is well represented;

(2) The narrow forest galleries do not influence recording;

[1] The original text of this paper, submitted by France, under the title "Note de l'Institut géographique national sur l'utilisation des vols APR (Air Profile Recorder) au-dessus de la forêt équatoriale", appeared in French as document E/CN.14/CART/26.

(3) The average dense forest with trees of unequal height gives an appreciable ground profile;

(4) The dense forest with trees of unequal height sometimes gives a profile which is fairly close to that of the tree tops while being clearly below the tallest trees; sometimes the profile obtained is much nearer that of the ground;

(5) In dense forest regions where the trees are of relatively even height the recorded profile seems to follow an intermediary line between the top of the vegetation cover and the ground.

It happens, moreover, that in places the APR profile passes beneath the ground. This is due to the fact that this profile, scribed from the 1:50,000 map is itself imprecise because the plotter who compiled the map naturally could only estimate the top of the vegetation, the height of which varies in these regions from 10 to 50 m.

Conclusions

Before trying to draw any serious conclusions from these experiments, it is therefore necessary to determine on the ground by cross-riding and direct levelling an exact profile of the terrain along the flight axis followed by the aircraft.

It does seem, however, that in regions of this type the APR cannot be used for the direct determination of the plotting control, whatever the scale of the plates and the survey to be effected. Nevertheless, its use might supply a control network of main points, at a sufficient distance from each other for the influence of the mean error on their absolute altitude to be negligible, on which an aerial traverse might be based. The APR flights will then be effected following the lines of a more or less regular grid (for example 50 km. apart on an average) but with a very high degree of tolerance on the routes of these flights, which will make it possible for them to be carried out in the most convenient places, account being taken of the terrain and of the photographic coverage to be equipped.

The grid nodes, i.e. the intersections between obviously perpendicular profiles, will afford the possibility of carrying out a general adjustment of the network, as in the customary method; and it will then be sufficient for some profiles to cut the precision levelling network for all points on any profile whatever to be landmarked. There will, therefore, be great latitude in selecting the supports for the aerial traverse, and advantage of this will be taken to select the most suitable points after examination of the photographic coverage.

This method is obviously less advantageous than the method used by the IGN in the Sahara for it does not eliminate aero-triangulation. It does, however, eliminate all barometric traversing on the ground and enables the value of the results of aero-triangulation to be kept at least equal to the value of present results.

MAP ON THE SCALE 1:20,000 OF A REGION WITH LITTLE RELIEF AND PARTLY WOODEN WITH ALTIMETRIC CHECKING OF MOSAICS[1]

As a preliminary to the drainage surveys to be carried out by the rural engineering services for the development of the irrigated cotton lands in the valley at the mouth of the Mangoky River, the Malagasy Geographical Service was instructed to make a rapid topographical survey of the area in question, together with a detailed inventory of the soil.

The area to be mapped was about 6,000 square miles.

The area generally is on two planes sloping gently downstream on both sides of the river; the extreme heights range from 60 m. upstream to one or two metres near the sea. The area to be surveyed is in the alluvial plain and delta; there are not any very definite topographical features and the ground shows traces of the successive beds of the river and the deposits carried down by the floods during the rainy seasons.

More than half of the area is covered with thick dry forest and the remainder consists of shrub or tree steppe; some seasonal crops are cultivated near the main and secondary beds of the river.

The present 1:100,000 map is already out of date, although revised in 1950 according to the general coverage of the Island on the scale 1:40,000, effected at that time by the Institut géographique national; it is also obviously inadequate for an inventory which should be sufficiently detailed to show precisely those areas where the soil would be suitable for cotton growing and for irrigation.

It was also quite obvious that the accuracy of the altimetrical data was much more important than a strict determination of planimetric details. Nevertheless, the fact that one half of the area was covered by woods did not allow the use of photogrammetric surveys.

It was decided to make a survey on the scale 1:20,000 from an altimetric controlled mosaic made up from an aerial survey on the same scale, carried out for that purpose.

Establishment of a controlled mosaic

The existing first order geodetic network was checked by a detailed control (density one point every 10 km.) established by the classic triangulation method. This relatively indeterminate control was checked in the studio by graphic triangulation (the so-called triangulation by means of radial slotted templates) and was used as a base for the rectification of the photographs finally assembled in a mosaic of the zone and presented in a

[1] The original text of this paper, submitted by the Malagasy Republic, under the title "Cartographie au 1:20,000 d'une région à très fauble relief et partiellement boisée par complément altimétrique de photoplans," appeared in French as document E/CN.14/CART/51.

collection of sheets from the base map on the scale 1:100,000.

In the absence of any considerable variations in level in the zone covered by each photograph, it can be taken that the positioning error in planimetric details with reference to the local relief is less than $\frac{1}{3}$ mm. (which under the most unfavourable conditions would correspond to a maximum variation in level to 8 or 10 m., taking into account the focal plane of the photographic apparatus).

The error thus theoretically imputable to the relief under the most unfavourable conditions is in any case less than the deformations occurring in the photographs themselves when they are being assembled and pasted together. The controls carried out during the vertical checking in the field have shown that they are practically less than one millimetre in the overlaps of the photographs themselves.

The original mosaic is made up of bromide prints of the corrected photographs, pasted on to a stable support (zinc or better still aluminium). After squaring this original is reproduced on sensitive paper backed by a polystyrene negative film.

This print is the operator's field sheet, which he takes on to the terrain for altimetric checking.

In addition to the automatic positioning of the horizontal details, the use of the mosaic also lightens the operator's task. When fitting the mosaic, one photograph out of two is used in a strip, so that the stereoscopic examination of the mosaic itself and of the photograph which is not used for the mosaic makes the reading much easier.

Altimetric survey

Bearing in mind the final aim (irrigation crops), great care must be taken in fixing the altimetric points. It will be necessary to carry out a dense network of geometric precision levelling, which will be indispensable subsequently as a base document for the rural engineering service in carrying out its drainage schemes (network of irrigation canals), and necessary also for determining with sufficient precision the altimetry of the map on the scale 1:20,000 and of later detailed surveys on a larger scale in regions pronounced suitable for the crops contemplated.

This network is based on the First Order levelling already carried out in the region, and constitutes finally a mesh of such density that topographers do not have to carry out traverses exceeding 2 km. 500. These were done using the plane-table and a holometric alidade by the classical process, the density of the height points being 25 points per sq. km., on the scale of the survey, 1 point per sq. cm. It was necessary further to effect a delimitation of one reference point per sq. km. The tolerance fixed for points clearly defined on the ground (boundary marks, cross-roads, etc.) was:

0 m. 20 for 50 for 100 points;
0 m. 30 for 10 for 100 points;
0 m. 40 for a maximum disparity not to be exceeded.

For the interpolated point, the tolerances are the same, for 50 for 100 points to $t = 2\sqrt{2E+0.2\text{ m/m}\times E\times p}$, where p = the slope and E = scale number. The maximum allowable error is $2t$.

The survey was carried out in three campaigns of six months each in 1958, 1959 and 1960. On an average, 1,000 hectares per month were surveyed, varying according to area or field crew from 900 to 1,100 hectares per month. One of the most costly operations was the cutting of a path through a forest for eventual traverses.

Mapping of the surveys

The field survey was entered with a hard pencil and then fair-copied in the usual colours in indelible inks, without erasing the pencilling.

The silver print is then washed in a solution of cyanide of potassium with iodine additive and rinsed gently in water so as not to wash away the ink.

It should be noted that insufficiently indelible inks are liable to cause difficulties, and it is for this reason that, as indicated above, the pencilled tracing is not erased before treatment of the silver print.

The ordinary field sheet, with the usual conventional signs can now be used as the base for the actual map itself.

It can equally well be used as a survey record by placing any transparent sheet of suitable size (such as Cronaflex, vinylite, astralon) on the photo-map and then making a tracing.

Thus, it was possible to carry out in the relatively short period of about three years, including issue of the map, the cartographic survey of an area which the Malagasy Government hoped would benefit economically from the cultivation of cotton.

Naturally, the 1:20,000 map thus obtained is only one item out of the large documentation involved in the solution of the many questions involved. Successive mapping stages to be reached before actual planting of cotton begins are roughly as follows:

1st stage—aerial survey, geodetic network, mosaic. Scale: 1:20,000.

2nd stage—soil map, 1:20,000. Precision levelling and general survey on the scale of 1:20,000 of the whole area.

3rd stage—general development project for the region; pre-project irrigation and other works; approximate estimation of their cost. Choice of a solution.

4th stage—topographic mapping on the scale of 1:50,000 of areas selected for cultivation (in accordance with soil map data).

This map will be used for the actual irrigation scheme; it will plot irrigation canals of different sizes and the situation of the various works.

The survey was carried out in successive stages according to the funds available and could be used as the base for a cadastral survey if the area, after establishment of the network, is not sub-divided into parcels of too small a size.

A survey on the scale of 1:20,000 is of little value for an area of less than 10,000 hectares and, generally speaking, the scale of 1:10,000 appears of small value.

MEMORANDUM ON THE CONTRIBUTION OF AMATEUR PHOTOGRAPHY IN COMPILING TOPOGRAPHIC DOCUMENTS[1]

I. Introduction

This method of survey, to which we would draw the critical attention of technicians both as regards the principles of its application and the results obtained, should not be assimilated with what are henceforward the traditional photographic procedures. Its efficacy alone justifies the principles.

It can, and probably will be, still further improved, but it will never be more than a lively introduction to the techniques of photogrammetry.

These techniques, with their onerous equipment and specialized personnel in particular, still leave a lengthy operational period to the photographic processes used by the Kaolack division.

1. IMPORTANCE OF RURAL DEVELOPMENT

The object is to try to adapt the means at our disposal to the needs of development while striving to achieve complete efficiency down to the smallest details, and at the lowest possible cost.

The first step is to decide on the plans for the lay-out of the villages and their general organization.

While respecting the local customs of the social group, the siting must position the town in the most active area of its existing perimeter. It must organize the town by grouping trade and handicrafts in a central district, stimulate activities by allocating to the inhabitants regular allotments, marked with well-defined boundaries, properly connected by a road network based on a general plan, and thus instilling a feeling of security in land tenure. The impression of anarchy in traditionally-constituted villages in no way encourages investment in durable building. The allotment therefore binds the family unit to the land from which it derives its livelihood, to the village in the life of which it shares closely. It harmonizes the legitimate aspirations of the individual and his material possibilities: the first stage is increased general well-being.

In view of the detailed comments offered (see draft), everything possible should be done to increase the efficacy of the steps taken.

2. THE PART PLAYED BY TOPOGRAPHY IN THE TRADITIONAL METHOD

There are three quite distinct stages in the urbanization of a village. First, a plan is made of conditions obtaining on the spot. On this basis the town-planner works out his draft. When this has been approved, it is sent back to the topographer who is responsible for marking out the streets and dividing the ground plots.

(a) *Plan of conditions of the site*

This is made in accordance with the technical requirements of topography. All topographical details worthy of note are listed in relation to a polygonal line previously drawn, carefully measured as regards both angles and distances, and then mathematically checked for accuracy. Such details include contours of concessions, limits of property rights recognized by title deed, outlines of winding paths, and the situation of buildings, huts and various installations, wells, obstacles and important land depressions. A small village can easily involve the listing of from fifteen hundred to two thousand such items. On returning to his office, the land surveyor hands over his observations and sketches to the draughtsman. The latter takes the polygonal reference line as the basis for each point surveyed and interprets them by a conventional line or sign; a lenthy and tedious task for the technician who knows nothing of the terrain he has to chart.

(b) *The scheme*

This plan of the conditions existing on the site, a more or less faithful reproduction of everything to be found on the spot, is used as a guiding document for the town-planner's draft. In addition to the topographical data which guide and rectifies the draft formed in his mind, he must take into account the views expressed by the local community, together with the requirements of the regional authorities as submitted to him. He must shape a functional organization of a road system and small blocks of houses and land in accordance with the requirements of the community.

3. POSITIONING

As soon as the draft has been declared satisfactory, it is put into execution. The surveyor then makes use of his original polygonal line to mark each angle of a plot of land, which is made permanent by a cement boundary-mark.

This is the final stage of the work. It opens up for the individual all the opportunities for development offered by tenancy or ownership within boundaries that can no longer be altered.

4. INTRODUCTION OF PHOTOGRAPHY

It is difficult to imagine how the work of the town-planner or land surveyor who marks out the plots of land could be reduced. On the other hand, it is quite possible, by means of photography, to increase the productivity of the technicians in connexion with the survey of conditions on the spot. This, indeed, is often done by aircraft used for photogrammetry. But the capital investment is out of all proportion to the few hundred hectares of the villages to be covered at a distance of two or three hundred kilometres from the aerodrome. Besides, the aircraft is large, and consequently is never immediately available.

[1] The original text of this paper, submitted by Senegal, under the title "Note sur une contribution de la photographie "amateur" à l'établissement de documents photographiques", appeared in French as document E/CN.14/CART/58.

The foregoing considerations led to the idea of using small airclub planes carrying amateur-type photographic equipment. For some years past, this solution has been adopted very frequently by the Kaolack Agricultural Services.

In this case an excellent picture of the ground has to be obtained. It makes possible identification of the nature of crops and their advance on fallow lands and, by simple manipulations of the planimeter, evaluation of their extent. The mosaic obtained will be a faithful agrological document rather than a map.

5. GROUND PREPARATION

The plan of the site requires other safeguards, since it must be strictly to scale and because its reference plane is the horizontal. This leads to a description of the details of the method proper.

As in every regular survey, the polygonal line is first laid out and measured.

An 80 metre mean module is desirable for it permits a good distribution of points on the negatives. Each of its summits is marked in relation to fixed characteristic features near-by, such as corners of buildings, trees, wells and so on. A diagram of this kind greatly simplifies the search for the point on the negative.

When the polygon is used again for positioning work, it will obviate waste of time. While measuring the polygon, the contours, which are invisible on the photograph and which form the boundaries of the property as certified by a duly established title, must be marked.

Some points are also laid to check the levelling. fI they are selected on a visible site they may also serve as control points when the mosaic is made. Except in the case of the ossature, the marking of these details never leads to more than thirty additional measurements.

In accordance with tradition, the surveyor transfers his lines on to a 1:5,000 diagram as the work progresses. It is this oriented sketch which serves as the flight plan.

6. FLIGHT AXES

Since the shape of the workshop is usually elongated, the photographic optical axes are selected parallel to the greatest dimension of the terrain. They are placed 140 metres apart which gives a lateral overlap equal to one half of the plate. An effort is also made to secure a one half longitudinal overlap.

7. THE SETTING UP OF SURVEY POLES

The boundaries of each of these axes are temporarily positioned on the ground by alternate orange and white strips of cloth which the pilot sees at first glance. They are laid out 150 or 200 m. in front of the area to be surveyed in the proper sense of the word. The polygon stations and the land title boundary stones are also shown, though in an infinitely less striking manner, by squares of flexible plastic material with sides measuring 70 cm. A hole is punched in the centre of each, through which the top of the pole indicating the summit is passed. It is possible that some shiny white material other than "Begilac" might prove better. In present circumstances this plastic material is very easily manipulated and preserved and reflects light very well. These mobile features are put in place before the aircraft passes, and subsequently removed.

8. PHOTOGRAPHING

Photographing is done on bord a "JODEL 110" or "120", its relative speed being 140 km. per hour. As care is taken to carry out the mission by flying against the wind, the drag is somewhat lessened and the photographer has more time to release and set his camera shutter.

9. PHOTOGRAPHIC EQUIPMENT

The camera used is a 24 × 36 mm. camera, excellent for amateurs. In this case it is a "Foca Universel" with interchangeable lenses. The only criticism of it is that it is fitted with a roller-blind shutter (displacement at 1/25° of a second). The lens is also a 2.8 Oplar 50 mm. "Foca" lens. It is fitted with a yellow filter which counteracts the effects of the sun haze.

The same lens is mounted on the enlarger. The advantage of this arrangement is that it eliminates all risk of possible distortion by using the principle of the inverse return of luminous rays, better known as the "Porro Koppe principle". When a photograph is taken, the camera is, under the best conditions, set at the vertical with the aid of tubes fixed on the case. This positioning, which is not always easy in a small aircraft which is very sensitive to air currents, depends entirely on the photographer's skill. Taking account of these data, the flight is made at 600 m. above ground, the camera being open at 5.6-11 for a speed of 1/200° of a second.

Each negative covers approximately 430 × 300 metres. As a one half overlap is sought photographing has to take place every four or five seconds.

The film used is a 27° Scheiner Kodak panchromatic: panatomic emulsion. It is developed in a bath for fine grain films.

10. SELECTION OF DOCUMENTS

His mission completed, the photographer makes a complete set of 8 × 12 cm. prints, without worrying about scale. It is the surveyor's task to make a careful selection from them before handing them over for final enlargement to the 1:1,000 scale.

Several factors are taken into account in this selection.

In the first place, all negatives which are blurred owing to any move of the camera are eliminated. This happens fairly rarely but should not cause surprise, because in a flying club aircraft there is not much space for the photographer who works in an uncomfortable position.

The good photograph contains at least four stationed marked-out points (images of stations of the polygon) distributed in accordance with a regular quadrilateral on the edge of the outside quarter of the negative.

The choice is also influenced by the anxiety to make a continuous mosaic, without gaps, between the photographs, with a border sufficient for the slicing and sticking necessary for attachment to the support.

In the end, only about a quarter of the photographs are kept.

The negatives which are kept are set as shown above and insert.

II. Reduction to scale, rectification

These two operations are simultaneous. They are effected with an automatic 24 × 36 "FOC" enlarger fitted with the same lens as used when photographing. The tilting head which receives the image may be set in a fixed position during the exposure of the sensitive paper. Bevelled wooden pegs are sufficient for this purpose.

Bearing in mind the equipment used, the optical centre of the rectifying lens is in the same place as during photographing.

This means that the beam perspective is accurately reconstituted. Among other advantages, the optical axis of the lens is always perpendicular in the centre of the head, guaranteed by the assembling of the enlarger. The head receiving the image counterbalances the tilt of the negative.

Aware of these facts, the photographer performs his manipulations by adjusting the focussing rack (to increase or decrease lengths) and on the head to ensure correspondence with the markers of the measuring rod.

After these adjustments, when he considers the result has been achieved, he places the sensitive paper on the plate, exposes it and lifts it; the paper used is a contrast paper, Kodak Kodabrom Extra. Drying is done in the open air, without glazing for that considerably distorts and congeals the shrinkage.

After drying, shrinkage continues to the extent of about 1 mm. on a negative size 24 × 30 cm. This has to be taken into account when positioning the photographs and it is a simple question of skill on the part of the photographer.

Example of measurement

12. Compilation of the mosaic

The plates obtained can then be made to form a map. First they are assembled in a mosaic, preferably on linen-backed drawing paper upon which the polygon has already been marked. Each of these points is very easily identifiable on the rectified plate on a scale of 1:1,000. It is then a matter of positioning the second plates on the paper background and fixing them in this position by pasting them carefully.

This is done very easily by means of an illuminated transparent table, or thick glass illuminated from below. The photographic glue "Despé" has given good results. It should be dried in a press.

This mosaic constitutes the plan of the village; it only remains for the draughtsman to interpret and trace each detail.

13. Remarks

Two comments should be made on the above method as explained. The use of the blind-shutter is open to much criticism. No mention has been made of the configuration of the terrain.

(a) *The shutter*

A shutter fitted with a blind or curtain, whatever results it may give, is liable to a lag. A curious detail, however, is that the pressure does not diminish so much as the calculations would lead one to think. On the other hand, squared marks appear as so many rounded figures,

whereas one might expect to obtain elongated forms, slightly rectangular (see figure 3). This very probably arises from the fact that the photograph is taken at a relatively low speed. Nevertheless, for the flights of the coming season Mr. Lefevre, the photographer at Kaolack, upon whom redounds the credit for the arrangement of the photographs and the work of rectification, proposes to use a Focaflex 2 with a 2.8 Neoplex 50 mm. lens with a central shutter. The interchangeability of the lens will still enable it to be mounted on the enlarger as under present conditions. It is thus possible to achieve the optimum conditions of 24 × 36 mm. aerial photography with equipment which is not specifically designed for the purpose.

(b) *The aspect of the ground*

The ground should be, in the words of the best text books on the theory of photogrammetry, flat and horizontal in configuration. At Sine-Safum we have precisely an opportunity of reaping the benefit of this theoretical advantage. Moreover, a village is usually too small for it to be made to climb a series of uneven heights and prefers areas of easy access and uniform relief. It seems that this is a method which can generally be used in cases of subdivision of plots.

14. Plans produced in this way are obviously subjected later to sample field checks. The results are recorded in two distinct series. The first deals with measurements made along lines parallel to the line of flight. The effect of employing the blind-shutter, a doubtful element, is emphasized in relation to the results given by the second series of data, those showing measurements taken along lines perpendicular to the line of flight. The effects caused by the shutter are practically nil in this case.

As a simple reference, to enable these ideas to be assessed and conclusions to be drawn, the standards of the French cadastral system as regards tolerances are cited. These correspond to distances controlled by a tacheometer survey on the scale 1:1,000.

Graphic distances are measured on the final document which is reproduced by the dry method.

Table 1. Control lines parallel to the line of flight

Chain distances	*Graphic distances*	*Deviations*	*Tolerances*
67.75	67.1	+0.65	0.61
50.06	50.0	+0.06	0.56
40.75	41.0	+0.25	0.53
19.83	19.7	+0.13	0.47
37.15	37.0	+0.15	0.50
43.00	43.5	−0.50	0.54
69.65	69.0	+0.65	0.61
24.77	25.0	+0.03	0.47
192.55	191.5	+1.05	0.89
78.05	77.5	+0.55	0.64
36.05	36.3	−0.25	0.51
120.70	119.7	+1.00	0.74

Table 2. Controls on the perpendicular lines along the axis of flight

Chain distances	*Graphic distances*	*Deviations*	*Tolerances*
127.60	127.5	+ 0.10	0.76
116.47	116.5	−40.03	0.68
57.50	57.5	0	0.58
117.55	117.8	− 0.25	0.73
23.50	23.7	− 0.20	0.47
127.55	127.2	+ 0.35	0.76
96.20	96.0	+ 0.20	0.69
62.50	62.5	0	0.59

The results obtained with this equipment during a single mission serve both as an example and to emphasize the advantage of using a central shutter. The reason why it was given only a limited trial and was not immediately put into general use was that the lens was fixed on the apparatus, which would not allow of satisfactory correction of possible errors by using the principle of the inversion of the luminous rays. The lens used for the photographs was a "Focasport" with a 45 mm. focal distance, while the enlargement lens was 50 mm.

The mere difference in focal length affects many aspects of the matter. Whenever the focal length of the camera lens differs from that of the lens of the enlarger, the latter should be tilted at a slight angle when rectifying an inclined negative.

When the mission takes place under particularly favourable conditions, most of the negatives are very close to the horizontal and the angle of the decentring of the lens may be almost a right angle. But good photography conditions are much reduced on a Jodel, and decentring cannot be done with the equipment in question.

Table 3. Results obtained with a central shutter camera (all directions)

Chain distances (m.)	*Graphic distances (m.)*	*Deviations (m.)*	*Tolerances (m.)*
49.80	50.0	− 20	0.56
57.65	57.9	−0.25	0.59
56.80	56.5	+0.30	0.59
49.62	49.5	+0.12	0.56
70.10	70.5	−0.40	0.61
112.55	112.4	+0.15	0.72
45.35	45.0	+0.35	0.55
77.70	77.5	+0.20	0.63
81.50	81.3	+0.20	0.64
86.68	86.9	−0.22	0.65

15. REVIEW OF RESULTS

The accuracy of detail of the survey appears to be sufficient. It must not be forgotten that all the important elements have been surveyed using the classical methods. These are buildings constructed in concrete or stone, the limits of property rights, wells, etc... The plan should provide a clear image upon which the projector attempts to limit the disturbance which the arrangement of islands causes at road junctions. The degree of accuracy must be such that the town planner may be certain, when positioning, that buildings and obstacles which he wished to avoid are not situated, for example, on a public right of way. The proposed plan largely fulfilled these exigencies.

16. ECONOMY OF THE METHOD

From the point of view of cost, one can only make a comparison with the results obtained by the traditional method on terrain comparable with that mapped by photography.

At the beginning of the year the Kaolack division began a survey, on the ground, of two villages of the Sine-Salum. They were Keur-Yorodu, with an area of 12 hectares and Mabe of 40 hectares. The cost of producing the documents is detailed in the table below:

Table 4. Production costs by ground survey

Place name	*Area (ha.)*	*Cost of ground personnel*	*Draughtsman*	*Total (fr.)*
Keur-Yorodu	12	74.350	33,300	107,650
Mabe	40	176,600	66,600	234,200
				341,850

The contribution of aerial photography to a survey showing the condition of an area before it is divided into plots lowers production costs very considerably.

The survey of the villages of Fass, with an area of 12 hectares, and Wack N'Guna (40 hectares) provides a close enough comparison of the costs of the two methods.

Table 5. Production costs by aerial photography

Place name	*Area (ha.)*	*Ground personnel*	*Photographs*	*Cost of aircraft*	*Draughtsman*	*Total (fr.)*
Fass	12	9,100	8,000	3,500	11,000	31,600
Wack N'Guna	40	18,000	16,000	10,500	21,800	66,300
						97,900

The cost of ground personnel included both their monthly salaries as well as their travelling expenses.

Aircraft expenses, however, included the cost of covering not only these two villages but other places at the same time. Costs would have been the same had only one topographic mission been carried out at a time. For practical purposes, photo-flight schedules are so arranged that two or three villages are covered at the same time, and this reduces the cost of each operation. This allows a considerable saving in the cost of fuel, although it is not possible to give exact figures.

Aerial photography was employed precisely because of this saving in costs.

Demand at present exceeds staff possibilities and therefore everything possible must be done to accelerate the rotation of teams.

A comparison can be made of the time spent on each of the operations, the cost price of which has been calculated.

Table 6. Duration (ground survey)

Place name	*Area (ha.)*	*Ground personnel (days)*	*Calculator draughtsman (days)*	*Total work days*
Keur-Yorodu	12	17	20	88
Mabe	40	29	40	185
				273

Table 7. Duration (with the help of aerial photography)

Place name	*Area (ha.)*	*Ground personnel (days)*	*Calculator draughtsman (days)*	*Total work days*
Fass	12	2	7	16
Wack N'Guna . .	40	4	16	32
				48

17. ADVANTAGES

These figures call for no comment. Quite independent of any financial economy, it is the saving of time which provides the real value of aerial photogrammetry. And this was the deciding factor in employing it. Certain other aspects, however, should be underlined.

Above all, the use of an aeroplane is very flexible. It can be sent out at a moment's notice on a given course, restricted only by atmospheric conditions; moreover, landing strips are of modest proportions and widely distributed over the national territory.

The photographic and enlarging apparatus is uncomplicated and costs relatively little. Furthermore, the method provides, from an instructional point of view, an introduction to the difficulties of photography. It familiarizes the draughtsman with the photographical identification of details.

For this purpose he uses a stereoscopic plaquette and a series of 8 × 10 cm. negatives, and thus has the opportunity of becoming acquainted with techniques which he will perhaps have to employ when using valuable equipment at some future time. Finally, it affords an introduction to the theories of photogrammetry, which are widely applied.

18. CONCLUSION

The economic aspect of aerial photography does not only apply to the division of land into plots but, generally speaking, to all topographical maps, charts and plans. It has been employed equally successfully for the preparation of evacuation plans, for general plans with a high density of levelling points, as well as plans for city street and road projects.

THE ORTHOPHOTOSCOPE, AN INSTRUMENT FOR DIFFERENTIAL RECTIFICATION[1]

By H. Belzner and H. Neubauer, Institut für Angewandte Geodäsie, Frankfurt am Main

The image details of original aerial photographs generally show displacements for two reasons. One reason is the inclination of the plane of the film relative to the horizon in the very moment of the exposure. The elevation differences of the terrain taken will result on the other hand in displacements of details. The first kind of errors may be entirely corrected by normal rectifiers if the terrain is plane. Those errors which have been caused by the shape of the terrain may only be diminished to a certain degree by ordinary rectifiers if much more work and disproportionately more control points are applied. Trials to eliminate them by use of special instruments have been executed by Gallus-Ferber and by Prof. Lacmann some thirty years ago. They have been continued recently in the United States of America by Bean and others and in the Federal Republic of Germany.

Rectifiers for this purpose are mainly characterized by the fact tha' the distance between the projection lens and the plane of projection will be modified during the exposure in accordance with the differences in elevation and that the exposure will be subdivided into small strips. The Orthoprojector Zeiss-Gigas has been constructed according to this principle and by applying modern electrical construction elements. It will work in connexion with the Zeiss-Stereoplanigraph (or any similar spindle-driven Stereoplotter). Both instruments will be coupled indirectly by intercalating a storage system. A stereomodel will be oriented relatively and absolutely in the Stereoplanigraph using conventional methods. Instead of plotting the information furnished by the model point by point or line by line, as usually it is now necessary to scan the elevations of the model's surface strip by strip. This scanning follows parallel straight lines (profiles) of equal width and equal length which are directed in the y direction. The speed of the scanning may be modified according to the actual shape of the terrain. Additional construction-elements are attached to the Stereoplanigraph allowing the storage of the elevation values and of other data of the profiles. The storage values will be fed into the Orthoprojector.

After realization of the internal and exterior orientation of the aerial image to be projected by using the setting data of the Stereoplanigraph the Orthoprojector executes automatically the complete rectification. For that purpose a diaphragm travels at constant speed across the sensitive material (paper or film) exactly reproducing the scanning operation in the Stereoplanigraph. By lifting or lowering the projector the projection distance will be modified relative to the fixed projection plane. The variation of the projection distance and the course of exposure is controlled by the stored data in a fully automatic way.

The projection system used in the Orthoprojector corresponds exactly to that of the Stereoplanigraph. This construction assures that any image point will be projected with maximum sharpness. The introduction of the storage system allows to separate in time and space the measuring and the exposure operation, as well as an interruption of measurement at the Stereoplanigraph, and a repetition of exposure by the Orthoprojector without scanning again the stereo model in a stereoplotting apparatus. The scale in the Orthoprojector may be modified relative to the scale of stereo model in the Stereoplanigraph that means mainly enlarged.

The result of this work is a differentially rectified and true to scale photomap showing an exact orthogonal projection of the terrain.

These "Orthoprojectormaps" have two essential advantages: Contrary to simple photomaps prepared by use of the conventional methods they are free of any error caused by the shape of the terrain. All the details of the earth's surface which are photographically fixed are preserved, on the other hand, contrary to maps prepared by any graphical plotting procedure of aerial photographs, containing necessarily but a selection of the information contents of the image. Moreover it is possible to spare much time compared to other procedures of map making.

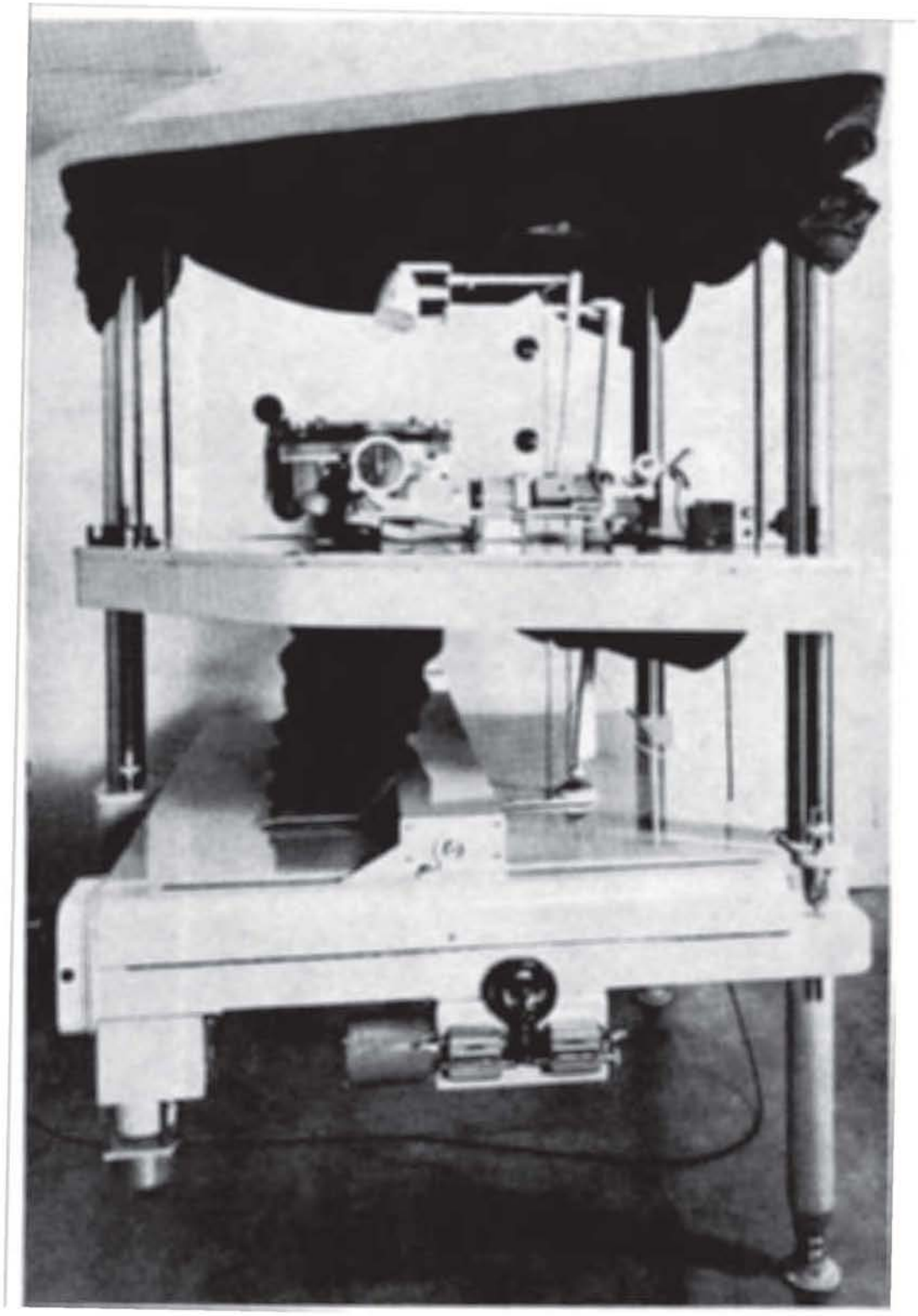
Orthoprojectormaps may be applied in the following fields: Preparation of base material at any scale for the making and revision of map series of all kinds; preparation of photographic cadastral plans giving even the possibility to show boundary marks if these had been signalized before the photographic flight to be visible from the air; supply of base material for the planning of construction- and development projects of all kinds and of basic maps to compile the results of the interpretation of air photographs.

The tests executed proved the expectations that the planimetric errors of Orthoprojectormaps remain in the order of magnitude which always must be expected when preparing maps graphically.

During a test with wide angle air photographs, 1:8,000 (taken with RMK 15/23, height of flight 1,200 m.) and differences of elevation up to 100 m. within the stereo model, 100 points have been planimetrically checked, the position of which is known with high precision. By signalization before the photographic flight they had been rendered visible from the air. The result was a mean square error of a point (absolute planimetric error) of ± 0.3 mm. ($= \pm 0.01$ inch) in a map at the scale of 1:3,000 with an average inclination of the terrain of about 13% ($= 8^g$) with maximum values of more than 30% ($= 20^g$). The greatest planimetrical error amounted to 0.73 mm. ($= 0.03$ inch) at a slope of some 30%.

The principle and the construction of the Orthoprojector offer a view on different additional possibilities for automation and thus on a further rationalization of photogrammetric mapping.

[1] The original text of this paper, contributed by the Federal Republic of Germany, appeared as document E/CN.14/CART/70.



Orthoprojector System Gigas-Zeiss

THE CONTRIBUTION OF AERIAL PHOTOGRAPHY TO THE DEVELOPMENT PROJECTS IN U.A.R. [1]

By Eng. Moh. A. F. Mohsen

Introduction

In the past ten years the increasing dangers of over-population and its effect on economic development was felt to be a real problem all over the whole world. This problem has to be solved in U.A.R. by speeding up the development of the reserves and raw materials, carrying out land reclamation projects, improvements in the field of agriculture and maximum utilization of raw materials. Without maps it is impossible to carry out any study concerning development projects. Aerial photographs are the most economical and efficient means known to us at present for preparing topographic, soil, geological maps.

General application of aerial photography

In recent years aerial photographs have become extremely important for soil survey purposes and I believe that one of the essential requirements to successfully perform soil survey is good aerial photography at a suitable scale. The soil map can be produced showing the distribution of various soils occurring in a particuiar area. There are several types: detailed, semi-detailed and reconnaissance. They serve different purposes in particular those of land reclamation, and selection of suitable areas for agriculture.

The aerial photograph is a valuable aid for location and preliminary planning of roads, railways, new cities and villages. After being supplied with elevation points it may aid in preliminary location of canals, in addition it can be used for determining shore lines, drainage lines and swamps.

In geological field the aerial photographs speeds up and facilitates prospecting in different parts of the country and some faw examples will be given later to illustrate how helpful can be the aerial photographs in this connexion.

An important role of aerial photographs is producing topographic maps.

Photogrammetry is the branch of science which deals with converting aerial photographs to topographic maps. There will be a slight discussion concerning this item when analysing the different aids of aerial photographs to the new valley project in U.A.R.

The major projects in U.A.R.

The high dam

This dam which is constructed in Upper Egypt to the south of Aswan is considered to be one of the biggest dams in the world.

One of the benefits of the project is to increase the present cultivated land in U.A.R. by about 30%. The first problem which existed was how to carry out very quick reconnaissance soil survey to make selection for the suitable area to be cultivated. For this purpose a semi-controlled mosaic at a scale 1:50,000 was constructed. It covered a total area of about 20 million feddans lying in the desert fringes of the Nile valley in the coastal belt of the Nile Delta. A reconnaissance soil survey and semi-detailed one for an area of about 11 million feddans was carried out and revealed the suitability of 650,000 feddans till now.

The preliminary investigation and study of the site of the dam was carried out by the help of 1:25,000 scale topographical maps with 5-metres contour interval prepared from wide angle photography.

Baharyia-Helwan railroad

After the discovery of iron ore in Baharyia area, there was the problem of finding a means for carrying the ore to the steel works and this problem has been solved by carrying out a feasibility study and preliminary design of the railroad to be constructed between the terminal points. Two general routes were studied:

(*a*) The direct road from Baharyia oasis to Cairo;

(*b*) The route due east to meet the river Nile.

The execution of the work continued according to the following steps:

(*a*) A reconnaissance survey of the entire area between terminal points to define in general the possible railroad routes locations, controlling topographic features, soils and rocks according to their engineering characteristics, geology and drainage. The reconnaissance had been carried out by traversing the region with vehicles and aircraft and this went side by side with a stereoscopic study of small scale aerial photographs. The results of the previous study were keyed to a controlled mosaic at a scale 1:50,000;

(*b*) A reconnaissance of alternative routes was carried out and for this purpose a stereoscopic photo coverage with aerial photography at a negative scale of 1:50,000 was executed. The aerial photographs covered the chosen strips which were of approximately 15 km. wide along the alternative routes of the railroad. A precision camera with 6 inches focal length lens and 9 × 9 inches format had been used. The forward overlap was nominally 60% and the side lap was 30%;

(*c*) A detailed reconnaissance for the selected route was the expected effort to be worked out and it was necessary to compile topographic maps at a scale 1:10,000 with contour lines at 8-metre interval with intermediate form lines at 2-metre interval. These maps have been compiled from aerial photographs at a scale 1:10,000, the instrument used for this purpose was the Kelsh plotter. Besides a photo interpretation study had been carried out for soil, location of sand dune areas, construction materials for embankment, aggregate and ballast. All this information was plotted on the 1:10,000 topographic maps;

[1] The original text of this paper, submitted by the United Arab Republic, appeared as document E/CN.14/CART/74.

(*d*) Preliminary design was executed. The preliminary centre line was projected with kilometre stationing, angle of intersection of tangents and the degree of curvature of each curve;

A centre line profile was drawn at 1:10,000 horizontal scale and 1:500 vertical scale to show the percent gradients of the line, structure of sand dune crossing area and soil conditions;

(*e*) To make an estimate of quantities the preliminary cut and fill grading quantities were computed by an electronic computer.
The number, length and spans of drainage structures and bridges were estimated.

As a conclusion it was felt that the combination of photogrammetry and electronics has made it possible to carry out precise measurements and perform computations much more economically than by ground survey and conventional computation methods.

Application of aerial photographs to geological mapping and mineral resources surveys

The use of aerial photographs to assist and accelerate geological mapping was pioneered in U.A.R. by the geological survey and mineral research department in late 1956. Near vertical photographs at a scale of 1:20,000 and 1:40,000 taken by the 6 inch aviogon lens were used.

The interpretation of the aerial photographs resulted in:

(*a*) Facilitating prospecting in different parts of the country;

(*b*) Refining pre-existing geological maps previously carried out by conventional survey methods;

(*c*) Tracing the upper cretaceous formations that contain phosphate deposits at Nile valley, Western desert and this work had been executed with greater accuracy from aerial photographs;

(*d*) It was possible through photo interpretation to locate outstanding shear zones that contain copper, lead zinc deposits in the eastern desert;

(*e*) Field parties working at desert regions did valuable work in tracing and directing prospecting for iron ore deposits by using aerial photographs;

(*f*)Coal bearing units were followed very easily through examination done by geological parties on aerial photographs.

THE NEW VALLEY PROJECT

It is one of the major projects which is very much interesting to the people in the U.A.R.

The reclamation of the new valley comprises:

1. The careful study to check the suitability of an area of about 3.5 million feddans to be cultivated, and to make all preparations to cultivate the selected areas with the help of the underground water.
2. The construction of towns, villages and buildings.
3. The discovery of iron ore, granite and phosphates.

To go on with such kind of work the specialists, experts and engineers in U.A.R. were in great need of as much information on the characterization of the major soil areas and some more information that would be helpful in making general plans for future development of agriculture and the utilization of water and other resources and which will also be of value in road construction, town planning and other engineering projects. Good soil, geological and topographic maps must be at hand to facilitate the work of our experts.

In a vast area like the new valley which is of great economic interest all kinds of maps can be obtained by air photo-coverage and in this connexion I do believe that an important role is played by the superwide-angle photography.

An entire area which consists of about 223,000 sq. km. was photographed by using the super-wide angle lens with about 88 mm. focal length at a scale of 1:50,000 the forward overlap was about 60% and S.L. 30%, the flight was due north-south and the total area was covered by about 6,500 photographs and controlled mosaics at a scale of 1:100,000 was constructed.

A reconnaissance soil survey was conducted for the whole area. The soils were examined, described, classified in the field and delineated on the contact prints in the office with the aid of a scanning stereoscope. After delineating the natural features such as soils, stream courses and peaks and cultural features such as desert tracks, temples and wells on the aerial photographs at a scale of 1:50,000 the soil delineations were transferred from the aerial photographs to the controlled mosaics.

Magnetic profile lines were completed totalling more than 9,000 miles with flight altitude of about 500 ft. Line spacing and bearings were determined on the basis of using lines one mile apart in pairs spaced about 30 to 40 miles.

I think that preparing the topographic base map sheets for the area under development from the ultra wide-angle photography is somewhat interesting.

The various available instruments for the direct plotting of super wide-angle photography are Wild A9, B9, B8, some types of multiplex projectors and approximate instruments like the stereotope. If no equipment was available for the direct plotting of super wide-angle photography, existing instruments may be used for affine plotting where topographic maps can be made with the required accuracy by means of the affine plotting technique if $W = Q = 2g$ and this can be obtained with the aid of gyro-stabilized cameras.

The aerial triangulation can be carried out on the A9 machine and if IBM electronic computer is combined to the photogrammetric technique then the strip adjustment through this channel will guarantee rapid progress of the work while maintaining the required accuracy both in horizontal and vertical, otherwise a block adjustment with Jerie method will be successful.

In this connexion I believe that if we take advantage of the new developed equipments and techniques for distance measurement with the aid of electromagnetic waves (like the tellurometer) or with high-frequency modulated light (as in the case of the geodimeter) then we will reach a very good economical solution for the problem of field work.

PLACE OF AERIAL SURVEYING IN THE FULFILMENT OF THE CARTOGRAPHIC PROGRAMMES OF THE SURVEY OF EGYPT[1]

By A. M. Wassef, Ph.D., Survey of Egypt, Giza, U.A.R.

Abstract

Considerations of the progress of the mapping programmes of the Survey of Egypt in the last few decades, and the increasing demand for special survey projects for the planning of economic and social development, indicated the imperativeness of replacing the old field methods by aerial techniques and explains the rapid expansion of the air survey activities in the recent years.

The principal difficulties encountered in the course of introducing aerial surveying into the Survey of Egypt are analysed; and the successful approaches are reviewed.

The current and the prospective fields of application of aerial surveying at the Survey of Egypt are presented.

1. The progress of the mapping programmes of the Survey of Egypt

The fields of activity of the Survey of Egypt of the Ministry of Public Works embrace the establishment of the various orders of triangulation and levelling, topographical mapping, cadastral surveying, town mapping, crop surveying and the demarcation and surveying of development projects.

When the department was established in 1895, however, its most urgent task was the completion within ten years of a cadastral survey of the cultivable region for the re-assessment of the land tax. There was not enough time to establish a proper geodetic framework for this survey. Discrepancies therefore appeared between the sheets of the independently surveyed regions. The frequency and size of the discrepancies soon indicated that a revision of the cadastre was necessary. The Second Cadastre was started in 1921 to make new maps at the scale 1:1,000 based on a unified geodetic triangulation and, at the same time, introducing improved legislation. The cadastral sheets were to be published at the scale 1:2,500. A series of topographic maps at the scale 1:25,000 were compiled from the 1:2,500 sheets and half-metre contours were superimposed by interpolation from spot heights determined by spirit levelling.

Topographic mapping of the desert regions received much less attention. Until 1920 only scattered desert areas were surveyed to assist in the search for some mineral deposits, or for military purposes. Since then, however, the responsibilities of the Survey of Egypt have included the completion of the topographic mapping of the Country at the scale 1:100,000.

The preparation of large-scale town maps was initiated at the Survey of Egypt in 1906. The present standard scale for town plans is 1:500, but some towns are surveyed at the scale 1:1,000. Maps at the scale 1:5,000 are compiled from these sheets and the cadastral sheets of the adjacent countryside.

When World War II came to an end, and after years of the most creditable toiling by the classical field methods, the cadastral survey had covered 40% of the cultivable land. The 1:25,000 contoured sheets of the green region were complete but needed revision. Eighty townships had been mapped but the older sheets were out of date. We also had topographical sheets at the scale 1:100,000 for 40% of the total area of the country, but some of the sheets were not contoured.[2]

The size of the work which remained undone clearly showed the futility of carrying on with the traditional system. We therefore set to investigate the possibilities of aerial surveying.[3] The nucleus of an air survey division was installed at the Survey of Egypt in 1952, thus happily coinciding with the Revolution which overthrew the old régime and established the Republic.

The revolutionary plans for economic recovery and social development made further heavy demands on the survey potential available at that time. Many new projects were urgently required including the survey work needed to implement the Agrarian Reform Laws of 1952 and 1960, to plan and execute vast land reclamation projects, an extensive network of highways and roads, numerous new hospitals, fresh-water plants, power stations, schools and social centres.

The rushing-in of these projects spared very little time to push on the normal survey programmes (which would have considerably eased these tasks if they had been fulfilled), and it gave further impetus to the endeavour to establish aerial surveying in the Department.

The introduction of aerial surveying at the Survey of Egypt

Notwithstanding the obvious need for aerial surveying a number of difficulties cropped up and had to be ironed out to enable the new division to start with sufficient momentum. The principal difficulties were:

(I) The high prices of the photogrammetric equipment and the shortage of the foreign currency needed to import them,

(II) The shortage of personnel with adequate scientific and technological background, and

(III) Organizational difficulties arising from the lack of appreciation of the full impact of modern technology on the old art of surveying.

As these difficulties were likely to be met in other emergent countries they were treated in rather general terms in a communication [4] to the Geneva Conference on

[1] The original text of this paper, submitted by the United Arab Republic, appeared as document E/CN.14/CART/75.

[2] Murray, G. W. (The Survey of Egypt 1898-1948), Survey of Egypt paper No. 50, 1950.

[3] Wassef, A. M. (Air photography in relation to survey work in Egypt), Report, 1950.

[4] Wassef, A. M. (On the problems associated with the adoption of modern survey techniques in the developing countries, with particular reference to experience in U.A.R.), Agenda item A1.

the Application of Science and Technology for the Benefit of the Less Developed Countries which was organized by the United Nations in February 1963. Only the questions of professional training and the choice of equipment will therefore be further elaborated in the present paper.

(a) *Professional training*[5]

The operators of the instruments are recruited from the graduates of the Survey School of the the Survey of Egypt. This school was re-opened in 1957 primarily to train field surveyors. A candidate to this school must have passed the first part of the Secondary School Certificate. He is given courses in elementary mathematics and the principles of the field survey techniques in current practice for two years. After passing the final examination he joins the Department on probation for one year. Selection to join the air-survey division is based on considerations of the general level of intelligence, acuity of stereoscopic vision, inclination to systematic work and temperament.

The training of candidates for the higher levels of supervisory work is certainly a difficult problem. It is essential to have a good background in mathematics and the physical sciences. It is also necessary to have a sound foundation in geography, geology, agriculture and civil engineering, in order to develop a keen cartographic sense. Furthermore, the complexity of modern machines requires sufficient knowledge of the technology of modern instrumentation to enable one to locate the faulty component in an instrument when its performance falls below the permissible limits. The Survey of Egypt tackled this problem by offering opportunities for advanced studies in surveying and the related subjects to university graduates who took honours degrees in mathematics, engineering, physics, geology and (shortly) agriculture, thus helping to form a team of men whose pooled knowledge and experience should enable them to solve any practical problem and to promote and develop aerial surveying in the Country. At the same time this team will form the nucleus of the teaching staff in the Institute for Higher Training in Surveying the establishment of which is contemplated at present. It is felt that the setting up of such an institute in Cairo would effectively contribute to the solution of the problem of professional training in the cartographic arts and sciences for the benefit of many African countries who feel an acute shortage for properly trained personnel. One may therefore venture to hope that the United Nations will take interest in the project and help fulfil in it in the very near future.

(b) *Choice of equipment*

The selection of air survey instruments for the Survey of Egypt was based on the results of a series of researches designed to define the scope and limitations of different approaches to the problems of mapping from aerial photographs, bearing in mind the requirements of the mapping programmes of the Department, the available survey data and ground control, and the level of the local technical potential.[6]

The relevant results were:

1. For cadastral surveying and aerial triangulation the analytical approach was the more potent,

2. The standard types of the (so-called) second order plotters offered satisfactory solutions for most of the envisaged applications of aerial photogrammetry other than aerial triangulation and cadastral work,

3. The simple techniques of the determination of heights from parallax measurements could be satisfactorily developed for practical use by improving the method and subdividing the work so that a man of no advanced educational equipment could be quickly taught his part (the expensive plotting machines were thus relieved to do the work which really needed them),

4. The gyroscopic stabilization of the mount of the aerial camera was a practical proposition. The additional cost involved would be outweighed by the possible simplifications of the mapping procedure.

The equipment available (or will be delivered before the end of the year) consists of an OMI three-plate self-recording stereocomparator for aerial triangulation and cadastral work, a Zeiss (Jena) stereoplanigraph for research in large scale work, a battery of Wild A8 autographs, a battery of Zeiss stereo-metrographs, SEGV rectifiers, Wild enlargers, a point-transfer device, a Cambridge stereocomparator, an OMI multiplex, Casella slotted-template equipment, and sets of stereoscopes and stereometers. The photogrammetry division will have access to an IBM electronic computer. Aerial photography is undertaken by the Air Force using high performance survey cameras.

3. Current and prospective fields of application of aerial photogrammetry at the Survey of Egypt

Aerial surveying has so far been applied at the Survey of Egypt in the following fields:

1. Topographic mapping at scales ranging from 1:2,500 to 1:25,000.

2. High precision surface profiles by analytical photogrammetry.

3. Determination of spot heights for land reclamation projects, employing the simplified methods.

4. Short range bridging in regions where the available ground control is not dense enough to furnish full ground control for each stereoscopic model. Photography at high altitude for control work was also successfully employed in this connexion.[7]

[5] Mostafa, H. H., and Wassef, A. M. (Report on the scientific policy in the fields of surveying, geodesy and photogrammetry), Science Council, Cairo, 1958.

[6] Wassef, A. M., Ph.D. Thesis (University of London, 1950), Empire Survey Review, No. 81, 82, 84, 87 and 88 (1951-1953), Photogrammetria, vol. VIII, No. 2 (1952), vol. X, No. 2 (1953), vol. XII, No. 2 (1955), vol. XIV, No. 3 (1958), Photogrammetric Engineering, vol. XX, No. 4 (1954), Patents (U.K.) No. 719612 (1950) and No. 747343 (1953), International Archives of Photogrammetry, vol. XI-II (1954), vol. XII-I (1957), vol. XIII-IV (1962), Travaux de l'Association Internationale de Géodésie, tome 21 (1962).

[7] Wassef, A. M., and Yassa, G. F., Proceedings af the Second Arab Science Congress, Cairo (1955).

5. Preparation of maps for the villages and their natural extensions. A simple procedure was successfully developed to produce suitable maps at the scale 1:1,000.

6. Town maps at the scale 1:2,500 and at the scale 1:5,000 for town planning.

7. Experimental work on crop surveying from aerial photographs, employing panchromatic and infra-red films.[8]

It is planned to raise the productivity of the Air Survey Division of the Survey of Egypt within the next two years to enable it to undertake the following operations in the Second Five Year Plan (1965-1970).

(*a*) Topographic mapping at the scale 1:100,000 of 300,000 sq. km.

(*b*) Cadastral surveying of 2,000,000 feddans.

(*c*) Preparation of maps at the scale 1:1,000 for 900 villages.

(*d*) Town mapping for twenty townships.

(*e*) Crop surveying from aerial photographs, three times every year, covering 8,000,000 feddans each time.

(*f*) Large scale (1:2,500) contoured maps for some 750,000 feddans, partly from aerial photographs.

[8] Wassef, A. M., Technical reports to the Ministry of Agriculture, 1960 and 1961.

ADJUSTMENT OF AERIAL TRIANGULATION[1]

By Vice-Admiral A. Dos Santos Franco, Brazilian Navy, Director of the International Hydrographic Bureau, Monaco

1. Introduction

This paper deals with the least square adjustment of an aerial triangulation strip by the Verdin-Moreau method, to which have been introduced some sound simplifications.

It is well known that, in almost all methods of adjustment, corrections are computed for the machine coordinates; then the corrected machine-coordinates are transformed into ground-coordinates. However, in the Verdin-Moreau method, adjusted transformation elements are found for each stereo-model so that the machine-coordinates x, y and z can be directly transformed into ground-coordinates X, Y and Z, without any previous corrections.

In the original method, the adjusted horizontal ground-coordinates of the points observed along the strip are found in terms of the adjusted values of the azimuth A and the scale denominator K, computed for each stereo-model, and the adjusted heights of these points are obtained in terms of the adjusted values of the general tip Φ and the general tilt Ω, for each pair.

As the computations were somewhat extensive in their original form, the authors tried to simplify them, as described in the Belgian review "Photogrammétrie" (No. 43, March 1956), in an article by A. Verdin and E. Moreau. In fact, they pointed out that the horizontal adjustment is considerably simplified if the strips have a N-S or E-W direction. In addition, the height adjustment can always be simplified if Φ and Ω are small, as they usually are.

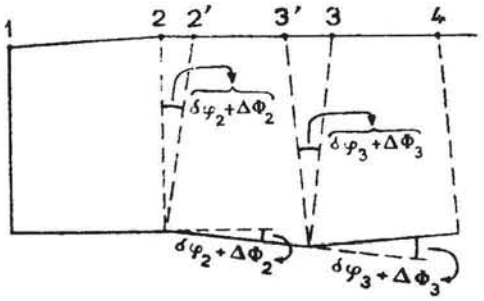
It will be shown later on that, if weights are not used, the simplification devised by the authors is a general one and not a special case of strips in a N-S or E-W direction. In this article will be given the complete theory as well as the practical application of the simplified method, which has been in use for some years in Brazil.

To simplify further development, it is convenient to explain how to find Φ for each stereo-model of the strip, both in the aerial-levelling and in the $bz = 0$ method.

To generalize the application of the method, the formulas will be derived in such a way that they can be applied to the three usual bridging methods, i.e., the aero-levelling, the aerial-traverse ($bz = 0$) and the aero-polygon, in which no values of bz are known beforehand.[2] Thus the general formulas will be derived to compute the successive values of the general tip Φ for the stereo-models by considering the aero-levelling and the aerial-traverse. In this way the aero-polygon can be looked upon as a particular case of the above-mentioned bridging methods.

It is well known that in both the aerial-levelling and the $bz = 0$ method it is always necessary, in each stereo-model, to modify the tip φ of the rear projecting camera, in order to eliminate the y paralaxes. Accordingly, projector i will have a φ tip in the $[(i-1), i]$ stereo-model, and a φ' tip in the $[i, (i+1)]$ model. The difference $\varphi' - \varphi = \delta\varphi$ is the Φ difference for the two stereo-models, as can be seen in the figure below. If we designate by Φ_{12} the residual tip of the first model 1-2, the tip of the model 2-3 will be:

$$\Phi_{23} = \Phi_{12} + \delta\varphi_2 + \Delta\Phi_2$$



Stereo model diagram

[1] The original text of this paper appeared as document E/CN.14/CART/83.

[2] The aero-levelling is performed by using bz values as given by the statoscope; the aerial-traverse is the Poivilliers method "Cheminement photographique à altitude constante" and the aero-polygon is the conventional method of bridging.

where $\Delta\Phi_2$ is the accidental error in the $\delta\varphi_2$ determination. By extension of the same reasoning, we have:

$$\begin{aligned}\Phi_{23} &= \Phi_{12} + \delta\varphi_2 + \Delta\Phi_2 \\ \Phi_{34} &= \Phi_{23} + \delta\varphi_3 + \Delta\Phi_3 \\ \Phi_{45} &= \Phi_{34} + \delta\varphi_4 + \Delta\Phi_4 \\ &\cdots\cdots\cdots\cdots \\ &\cdots\cdots\cdots\cdots\end{aligned} \qquad (1a)$$

In the aero-levelling, the $\delta\varphi$ values are approximately equal to the angle γ between the earth's rays correspondent to the positions of two successive exposures. In the $bz = 0$ method, this angle is also included in γ. In the aero-polygon, we have approximately $\delta\varphi = \gamma$. Thus we can see from expressions ($1a$) that each value of Φ contains the systematic accumulation of γ in all three methods of bridging. The effect of γ, or of any similar systematic error, can be ignored as they are eliminated in the adjustment process. Thus, in the expressions ($1a$), the values of $\varphi\delta$ are the φ differences read on the instrument's scale and will be zero for the free bridging.

2. Least square absolute orientation of the end pairs

The following development is concerned with a strip in which control points are available only on the first and last stereo-models. Therefore, the transformation formulas will be derived, and they will show which elements are to be determined in function of the ground control.

If x, y and z are the machine-coordinates of any observed point, and if K is the scale denominator of the stereo-model, the lengths on the ground will be Kx, Ky and Kz. If X, Y and Z are the ground-coordinates of the considered point, fig. 2.1 represents the instrument $xO'y$ coordinate system in relation to the ground XOY system for the planimetry, and fig. 2.2 shows the instrument plane xOy which is the datum for the height measurements. From fig. 2.1, the following formulas are immediately obtained for transformation of the plane coordinates:

$$\begin{aligned}X &= P + Kx\cos A + Ky\sin A \\ Y &= Q - Kx\sin A + Ky\cos A\end{aligned} \qquad (2a)$$

or, by putting

$$\begin{aligned}K\cos A &= e \\ K\sin A &= f,\end{aligned} \qquad (2b)$$

$$\begin{aligned}X &= P + ex + fy \\ Y &= Q + ey - fx\end{aligned} \qquad (2c)$$

Fig. 2.2 shows that the plane xOy is inclined to the horizontal plane and that the components of the inclination are Φ and Ω. Hence, the true height of a point V is given with sufficient approximation by:

$$Z = R + Kz + Kx\tan\Phi + Ky\tan\Omega$$

Now, as Φ and Ω are small, their tangents can be substituted by their respective arcs and the above expression can be written as follows:

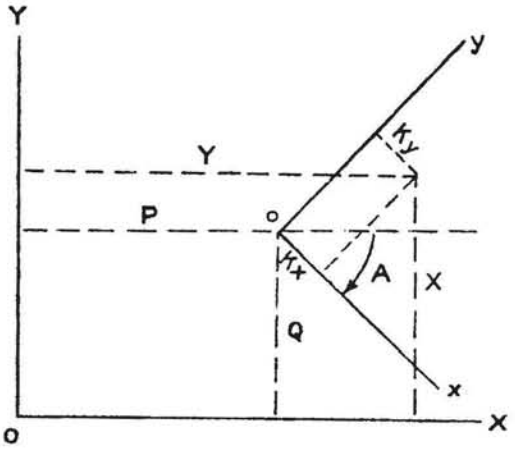
$$Z = R + Kz + K\Phi x + K\Omega y$$

or, by putting

$$\begin{aligned}K\Phi &= E \\ K\Omega &= F,\end{aligned} \qquad (2d)$$

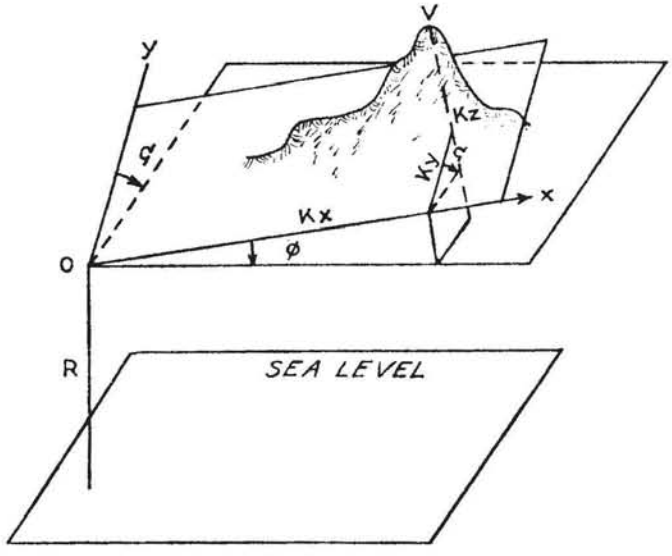
$$Z = R + Kz + Ex + Fy \qquad (2e)$$

Hence, if we determine P, Q, R, e, f. E and F in function of the ground control points, expressions ($2b$), ($2c$), ($2d$) and ($2e$) can be used to find the ground coordinates of any other observed point of the stereo-model.



Transformation of coordinates diagram

If more than two planimetric ground control points are known, P, Q, e and f can be determined by the least square method. Similarly, it may be used for R, E and F, if more than three ground control points are known. As the values of Φ and Ω are always very small, the horizontal and vertical adjustment can be treated independently. However, as the reasoning is the same for both problems, they will be treated together.



Height adjustment diagram

Let (X_1, Y_1), (X_2, Y_2), etc., be the horizontal ground coordinates of n points and Z_1, Z_2, etc., the true heights of n points, not necessarily the same. Then, if (x_1, y_1), (x_2, y_2), etc., are the horizontal machine-coordinates, and z_1, z_2, etc., are the instrumental heights, we

obtain from (2c) and 2e):

$$\begin{aligned} X_1 &= P + ex_1 + fy_1 & Y_1 &= Q + ey_1 - fx_1 \\ X_2 &= P + ex_2 + fy_2 & Y_2 &= Q + ey_2 - fx_2 \\ &\cdots\cdots\cdots & &\cdots\cdots\cdots \\ &\cdots\cdots\cdots & &\cdots\cdots\cdots \\ X_n &= P + ex_n + fy_n & Y_n &= Q + ey_n - fx_n \end{aligned} \qquad (2f)$$

$$\begin{aligned} Z_1 - Kz_1 &= R + Ex_1 + Fy_1 \\ Z_2 - Kz_2 &= R + Ex_2 + Fy_2 \\ &\cdots\cdots\cdots\cdots \\ &\cdots\cdots\cdots\cdots \\ Z_n - Kz_n &= R + Ex_n + Fy_n \end{aligned}$$

The sum of each of the above groups of expressions gives us the following expressions, where the Gaussian symbol for summation is used:

$$\begin{aligned} [X] &= nP + e[x] + f[y] \\ [Y] &= nQ + e[y] - f[x] \\ [Z - Kz] &= nR + E[x] + F[y] \end{aligned}$$

Now, dividing by n and putting

$$\begin{aligned} [X]/n &= X_g & [x]/n &= x_g \\ [Y]/n &= Y_g & [y]/n &= y_g \\ [Z]/n &= Z_g & [z]/n &= z_g \end{aligned} \qquad (2g)$$

we have

$$\begin{aligned} X_g &= P + ex_g + fy_g \\ Y_g &= Q + ey_g - fx_g \\ Z_g - Kz_g &= R + Ex_g + Fy_g \end{aligned} \qquad (2h)$$

Hence, if we introduce in (2f) the values of P, Q, and R taken from (2h), and we put

$$\begin{aligned} X - X_g &= X' & x - x_g &= x' \\ Y - Y_g &= Y' & y - y_g &= y' \\ Z - Z_g &= Z' & z - z_g &= z' \end{aligned} \qquad (2i)$$

then expressions (2f) may be simplified as follows:

$$\begin{aligned} X'_1 &= ex'_1 + fy'_1 & Y'_1 &= ey'_1 - fx'_1 & Z'_1 - Kz'_1 &= Ex'_1 + Fy'_1 \\ X'_2 &= ex'_2 + fy'_2 & Y'_2 &= ey'_2 - fx'_2 & Z'_2 - Kz'_2 &= Ex'_2 + Fy'_2 \\ &\cdots\cdots & &\cdots\cdots & &\cdots\cdots\cdots \\ &\cdots\cdots & &\cdots\cdots & &\cdots\cdots\cdots \\ X'_n &= ex'_n + fy'_n & Y'_n &= ey'_n - fx'_n & Z'_n - Kz'_n &= Ex'_n + Fy'_n \end{aligned}$$

The groups of expressions in X' and Y' are the condition equations for the horizontal adjustment and the group in Z' the condition equation for the height adjustment. Thus we have the following system of normal equations for the horizontal adjustment:

$$\begin{aligned} ([x'x'] + [y'y'])e &= [x'X'] + [y'Y'] \\ ([x'x'] + [y'y'])f &= -[x'Y'] + [y'X'] \end{aligned} \qquad (2j)$$

Similarly, we obtain for the height adjustment the following system of normal equations:

$$\begin{aligned} [x'x']E + [x'y']F &= [x'(Z' - Kz')] \\ [x'y']E + [y'y']F &= [y'(Z' - Kz')] \end{aligned} \qquad (2k)$$

The solutions of (2j) and (2k) give us all the terms of (2g), except P, Q and R. Hence values of P, Q and R can be computed afterwards. Forms 2-I and 2-II show the complete solution of the problem. Some readily comprehensible checking operations can be seen there.

Form 2-I

First pair

Points	x	y	$x' = x - x_g$	$y' = y - y_g$	X	Y	$X' = X - X_g$	$Y' = Y - Y_g$
PFP 16	1 680.80	−5 901.60	−1 192.60	−2 372.30	67 704.99	209 166.35	− 225.91	+2 113.36
PFM 33A	4 141.80	−5 661.00	+1 268.40	−2 132.20	66 153.24	207 936.77	−1 777.66	+ 883.78
PFP 14	4 049.50	−1 178.00	+1 176.10	+2 350.80	68 158.17	204 962.43	+ 227.27	−2 090.56
Δ P 15	1 621.50	−1 375.10	−1 251.90	+2 153.70	69 707.21	206 146.40	+1 776.31	− 906.59
Sums	11 493.60	−14 115.20	0.0	0.0	31 723.61	828 211.95	+ 0.01	− 0.01
Mean	2 873.40	−3 528.80	←(x_g, y_g)	Mean	7 930.90	207 052.99	←(X_g, Y_g)	

$S_1 = [x'x'] + [y'y'] = 26\,320\,366.60$ $\quad e = S_2/S_1 = 0.672741$ $\quad K^2 = e^2 + f^2 = 0.64048449$

$S_2 = [x'X'] + [y'Y'] = -17\,706\,764.90$ $\quad f = S_3/S_1 = +0.433479$ $\quad K = 0.800303$

$S_3 = -[x'Y'] + [y'X'] = 11\,409\,312.27$ $\quad tg\ A = S_3/S_2 = 0.644347$ $\quad A = 32^\circ\,47'\,44''$

$X_g =$	67 930.90	$Y_g =$	207 052.99
$-ex_g =$	+ 1 933.05	$-ey_g =$	− 2 373 97
$fy_g =$	+ 1 529.66	$fx_g =$	+ 1 245.56
$P =$	71 393.61	$Q =$	205 924.58

Check

$X_c = P + ex + fy$

$Y_c = Q + ey - fx$

$[v]_x = [v]_y = 0$

Points	ex	fy	X_c	$v = X - X_c$	ey	$-fx$	Y_c	$v = Y - Y_c$
	−1 130.74	−2 558.00	7 704.87	+0.12	−3 969.91	+ 728.59	209 165.89	+0.46
	−2 786.36	−2 453.92	6 153.33	−0.09	+3 808.38	−1 795.38	207 937.57	−0.80
	−2 724.26	− 510.64	8 158.71	−0.54	+ 792.49	−1 755.37	204 961.69	+0.74
	−1 090.85	− 596.08	9 706.68	+0.53	+ 925.08	+ 702.89	206 146.75	−0.35

Last pair

Points		x	y	$x' = x - x_g$	$y' = y - y_g$	X	Y	$X' = X - X_g$	$Y' = Y - Y_g$
PFA		27 398.10	−5 646.40	− 980.05	−2 173.23	50 436.15	197 822.36	− 287.47	+1 898.94
PF	23	29 455.80	−5 819.20	+1 077.65	−2 346.03	48 970.60	197 040.93	−1 753.02	+1 117.51
P	19	29 249.30	− 923.40	+ 871.15	+2 549.77	51 246.87	193 816.02	+ 523.25	−2 107.40
PFP	20	27 409.40	−1 503.70	− 968.75	+1 969.47	52 240.85	195 014.37	+1 517.23	− 909.05
SUMS		113 512.60	−13 892.70	0	− 0.02	202 894.47	783 693.68	− 0.01	0
MEAN		28 378.15	−3 473.17	(x_g, y_g)	Mean	50 723.62	195 923.42	(X_g, Y_g)	

$S_1 = [x'x'] + [y'y'] = 24\,426\,130.94$
$S_2 = [x'X'] + [y'Y'] = -16\,533\,671.72$
$S_3 = -[x'Y'] + [y'X'] = +10\,671\,672.88$

$e = S_2/S_1 = -0.676885$
$f = S_3/S_1 = +0.436896$
$tg\ A = S_3/S_2 = 0.645450$

$K^2 = (e^2 + f^2) = 0.64905148041$
$K = 0.805637$
$A = 32° 50' 25''$

Check

$X_g = 50\,723.62$
$-ex_g = +19\,208.74$
$-fy_g = + 1\,517.41$
$P = 71\,449.77$

$Y_g = 195\,923.42$
$-ey_g = - 2\,350.94$
$fx_g = + 12\,398.30$
$Q = 205\,970.78$

$X_c = P + ex + fy$
$Y_c = Q + ey - fx$
$[v]_x = [v]_y = 0$

Points	ex	fy	X_c	$v = X - X_c$	ey	$-fx$	Y_c	$v = Y - Y_c$
	−18 545.36	−2 466.88	50 437.53	−1.38	+3 821.96	−11 970.12	197 822.62	−0.26
	−19 938.19	−2 542.38	48 969.20	+1.40	+3 938.93	−12 869.12	197.040.59	+0.34
	−19 798.41	− 403.43	51 247.93	−1.06	+ 625.04	−12 778.90	193 816.92	−0.90
	−18 553.01	− 656.96	52 239.80	+1.05	+1 017.83	−11 975.06	195 013.55	+0.82

Form 2-II

First pair — $K_0 = 0.8$ — $K' = K/K_0 = 1.000379$[a]

	Points		x	y	z	$x' = x - x_g$	$y' = y - y_g$	$z' = z - z_g$	Z	$Z' = Z - Z_g$	$K'z'$	$Z' - K'z'$
1	PFP	16	1 680.80	−5 901.10	508.00	−1 192.60	−2 372.30	−10.07	507.99	−10.23	−10.10	−0.13
2	PFM	33A	4 141.80	−5 661.00	539.00	+1 268.40	−2 132.20	+20.93	539.44	+21.22	+21.00	+0.22
3	PFP	14	4 049.50	−1 178.00	499.30	+1 176.10	+2 350.80	−18.77	499.35	−18.87	−18.84	−0.03
4	Δ P	15	1 621.50	−1 375.10	526.00	−1 251.90	+2 153.70	+ 7.93	526.12	+ 7.90	+ 7.96	−0.06
	Sums		11 493.60	−14 115.20	2 072.30	0.00	0.00	0.02	2 072.90	0.02	0.02	0.00
	Means		2 873.40	−3 528.80	518.07	←x_g, y_g, z_g ←mean→ Z_g			518.22			

$a = [x'x'] = + 5\,981\,598.14$
$b = [x'y'] = + 193\,281.35$
$c = [y'y'] = +20\,338\,768.46$
$d = [x'(Z' - K'z')] = + 473.92$
$k = [y'(Z' - K'z')] = - 360.43$

$a/b = +30.947670$ $\quad d/b = +0.002452$
$-b/c = - 0.095031$ $\quad -k/c = +0.000018$
$D_E = +30.852639$ $\quad N_E = +0.002470$

$b/a = + 0.032312$ $\quad d/a = +0.000079$
$-c/b = -10.522900$ $\quad -k/b = +0.001865$
$D_F = -10.490588$ $\quad N_F = +0.001944$

$E = N_E/D_E = + 0.000080$
$F = N_F/D_F = - 0.000185$

$R = Z_g - K'z_g - Ex_g - Fy_g = 518.22 - 518.26 - 0.23 - 0.65 = -0.92$

Check

Points	Ex	Fy	$K'z$	Z_c	v
1. . . .	+0.13	+1.09	508.19	508.49	+0.50
2. . . .	+0.33	+1.05	539.20	539.66	+0.22
3. . . .	+0.32	+0.21	499.49	499.10	−0.25
4. . . .	+0.13	+0.25	526.20	525.66	−0.46

$v = Z_c - Z$; $\quad [v] = 0$

[a] K′ is used instead of K because gears for K_o were available to transform z readings in natural height differences.

Last pair			$K_0 = 0.8$						$K' = K/K_0 = 1\ 007046$[a]			
	Points		x	y	z	$x' = x - x_g$	$y' = y - y_g$	$z' = z - z_g$	Z	$Z' = Z - Z_g$	$K'z'$	$Z' - K'z'$
1 . . .	PFA		27 398.10	−5 646.40	736.50	− 980.05	−2 173.23	+28.50	713.20	+25.53	+28.70	−3.17
2 . . .	PFP	23	29 455.80	−5 819.20	735.50	+1 077.65	−2 346.03	+27.50	712.32	+24.65	+27.69	−3.04
3 . . .	P19	Δ	29 249.30	− 923.40	679.00	+ 871.15	+2 549.77	−29.00	660.43	−27.24	−29.20	−1.96
4 . . .	PFP	20	27 409.40	−1 503.70	681.00	− 986.75	+1 969.47	−27.00	664.73	−22.94	−27.19	+4.25
	Sums		113 512.60	−13 892.70	2 832.00	0.00	− 0.02	0.00	2 750.68	0.00	0.00	0.00
	Means		28 378.15	−3 473.17	708.00	←x_g, y_g, z_g ←mean→		Z_g	687.67			

$a = [x'x'] = +\ 3\ 819\ 206.41$ $\quad a/b = -\ 44.922850$ $\quad d/b = +0.030336$

$b = [x'y'] = -\ 85\ 017.09$ $\quad -b/c = +\ 0.004125$ $\quad -k/c = -0.001329$

$c = [y'y'] = +20\ 606\ 924.05$ $\quad D_E = -\ 44.918725$ $\quad N_E = +0.029007$

$d = [x'(Z'-K'z')] = -\ 2\ 579.05$

$k = [y'(Z'-K'z')] = +\ 27\ 388.87$ $\quad b/a = -\ 0.022260$ $\quad d/a = +0.006752$

$-c/b = +242.385920$ $\quad -k/b = +0.322157$

$E = N_E/D_E = -\ 0.000646$ $\quad D_F = 242.363660$ $\quad N_F = 0.328909$

$F = N_F/D_F = +\ 0.001357$

$R = Z_g - K'z_g - Ex_g - Fy_g = 687.67 - 712.99 + 18.33 + 4.71 = 2.28$

Check

Points	Ex	Fy	$K'z$	Z_c	v
1. . . .	−17.70	−7.66	741.69	714.05	+0.85
2. . . .	−19.03	−7.90	740.68	711.47	−0.85
3. . . .	−18.90	−1.25	683.78	661.35	+0.92
4. . . .	−17.71	−2.04	685.80	663.77	−0.96

$v = Z_c - Z$; $\quad [v] = 0$

[a] K′ is used instead of K because gears for K_o were available to transform z readings in natural height differences.

3. Adjustment of the strip

Before the derivation of the condition equations it is possible to introduce a considerable simplification into the development concerning the horizontal adjustment. As we have shown in section 2, if the adjusted values of P, Q, e and f are known for a stereo-model, then the ground-coordinates of every point observed can be computed by the expression (2*a*). Hence it will be very convenient to use the variables e and f, as did Verdin in his interpolation method. But A and K are independent variables and expressions (2*b*) show that both e and f are functions of A and K. However if we assign equal weights to A and K, it is very easy to prove that e and f also have equal weights and are correlation free, which seems paradoxical.

If we designate by ΔA, ΔK, Δe and Δf, the corrections to be applied to A, K, e and f respectively, we can differentiate the expressions (2*b*) and substitute the corrections for the differentials. Thus we have:

$$\Delta e = -K \sin A \Delta A + \cos A \Delta K$$
$$\Delta f = K \cos A \Delta A + \sin A \Delta K$$

Now, if we put

$$\Delta K/K = \Delta\lambda,$$

we can write

$$\Delta e = -K \sin A \Delta A + K \cos A \Delta\lambda$$
$$\Delta f = -K \cos A \Delta A + K \sin A \Delta\lambda$$

or, according to (2*b*),

$$\Delta e = -f \Delta A + e \Delta\lambda \qquad (3a)$$
$$\Delta f = e \Delta A + f A\lambda$$

If we compute the weight numbers by Tienstra's symbolic method, we have to substitute Δe, Δf, ΔA and $\Delta\lambda$ in (3*a*) by the symbols Q_e, Q_f, Q_A and Q_λ respectively. Thus,

$$Q_e = -fQ_A + eQ_\lambda$$
$$Q_f = eQ_A + fQ_\lambda$$

Hence,

$$Q_{ee} = f^2 Q_{AA} + e^2 Q_{\lambda\lambda} - 2ef Q_{A\lambda}$$
$$Q_{ff} = e^2 Q_{AA} + f^2 Q_{\lambda\lambda} + 2ef Q_{A\lambda}$$
$$Q_{ef} = -ef(Q_{AA} - Q_{\lambda\lambda}) + (e^2 - f^2) Q_{A\lambda}$$

Now, as A and λ are correlation free and we assign equal weights to A and λ, we have $Q_{AA} = Q_{A\lambda}$ and $Q_{A\lambda} = 0$. Thus we can conclude that

$$Q_{ee} = Q_{ff} \text{ and } Q_{ef} = 0.$$

Consequently, e and f also have equal weights and are correlation free. Therefore, it is possible to adjust directly the values of e and f.

Now we are in a position to derive the condition equations. If we look at form 2-I, we see that the values of P, Q, e and f differ in the first and last stereo-models. Thus we can write the literal form of the closing errors:

$$w_p = P_{(n-1),n} - P_{12}$$
$$w_Q = Q_{(n-1),n} - Q_{12} \qquad (3b)$$
$$w_e = e_{(n-1),n} - e_{12}$$
$$w_f = f_{(n-1),n} - f_{12}$$

In addition, form 2-II gives immediately the closing errors:

$$w_R = R_{(n-1),n} - R_{12} \qquad (3c)$$
$$w_F = F_{(n-1),n} - F_{12}$$

But the difference $E_{(n-1),n} - E_{12}$ is not a closing error, except in the case of the aero-polygon. In fact, we have

from (1*a*) and (2*d*):

$$\begin{aligned} E_{23} &= E_{12} + \delta E_2 + \Delta E_2 \\ E_{34} &= E_{23} + \delta E_3 + \Delta E_3 \\ E_{45} &= E_{34} + \delta E_4 + \Delta E_4 \\ &\cdots\cdots\cdots\cdots \\ &\cdots\cdots\cdots\cdots \end{aligned} \tag{3d}$$

where

$$\delta E = K\delta\varphi \tag{3e}$$

Thus, if we add the expressions (2*d*), we obtain:

$$E_{(i-1),i} = E_{13} + [\delta E_j]_3^{i-1} + [\Delta E_j]_3^{i-1}$$

For the whole strip we have $i = n$, and the sum of all values of ΔE will be the closing error. Hence

$$w_E = E_{(n-1),n} - E_{12} - [\delta E] \tag{3f}$$

Now the ground-coordinates X, Y and Z can be considered free from errors. Therefore, if we differentiate the expressions (2*c*), and (2*e*), the results will be as follows:

$$\begin{aligned} \Delta P &= -x\Delta e - y\Delta f \\ \Delta Q &= y\Delta e - x\Delta f \\ \Delta R &= -z\Delta K - x\Delta E - Y\Delta F \end{aligned} \tag{3g}$$

These errors have a cumulative effect; consequently if we add all the values for the whole strip, the sum of ΔP will be equal to w_P. With the same reasoning we can write the following condition equations for the horizontal adjustment.

$$\begin{aligned} -[x\Delta e] - [y\Delta f] &= w_P \\ [y\Delta e] - [x\Delta f] &= w_Q \end{aligned} \tag{3h}$$

The other two equations are obviously

$$\begin{aligned} [\Delta e] &= w_e \\ [\Delta f] &= w_f \end{aligned} \tag{3i}$$

For the height adjustment we have, from the last expression of (3*g*):

$$-[z\Delta K] - [x\Delta E] - [y\Delta F] = w_R \tag{3j}$$

and the other two will be:

$$\begin{aligned} [\Delta E] &= w_E \\ [\Delta F] &= w_F \end{aligned} \tag{3k}$$

All the condition equations are now derived and the adjustment problem can be resolved in a special manner. The method of solution that we have chosen, adjustment in two groups, was described by Wright and Hayford in their book, "Adjustment of Observations", (1906). The method was successfully used by the authors to adjust a central point polygon. But the so called "solution in two groups" was generalized by Tienstra as follows:

> "Every problem of adjustment may be divided into an arbitrary number of phases, provided that in each succeeding phase the co-factors resulting from the preceding phase(s) are used."

This possibility was considered by Tienstra as the principal property of the least square method. We shall use this property as the means of obtaining some important simplifications, in the same way as Wright and Hayford succeeded in doing in the adjustment of the central point polygon.

The first phase of the adjustment can be worked out by considering only equations (3*i*) and (3*k*). Each one of these equations is independent of the others, thence they may be adjusted independently. Thus a first group corrections is found in the usual manner:

$$\begin{aligned} \overline{de} &= w_e / (n-2) \\ \overline{df} &= w_f / (n-2) \\ \overline{dE} &= w_E / (n-2) \\ \overline{dF} &= w_F / (n-2) \end{aligned} \tag{3l}$$

where n is the number of photographs in the strip. It is easy to understand that these first corrections eliminate any systematic error, such as the above-mentioned one resulting from the curvature of the earth.

Now a new correction is needed to take into account the condition equations (3*h*) and (3*j*). Hence the total corrections can be written as follows:

$$\begin{aligned} \Delta e &= de + \overline{de} \\ \Delta f &= df + \overline{df} \\ \Delta E &= dE + \overline{dE} \\ \Delta F &= dF + \overline{dF} \end{aligned} \tag{3m}$$

These values can be introduced in (3*h*), (3*i*) and (3*k*), and the results will be:

$$\begin{aligned} -[x\,de] - [y\,df] - \overline{de}[x] - \overline{df}[y] &= w_P \\ [y\,de] - [x\,df] + \overline{de}[y] - \overline{df}[x] &= w_Q \\ [de] &= 0 \\ [df] &= 0 \end{aligned}$$

for the horizontal adjustment, and

$$\begin{aligned} -[z\Delta K] - [x\,dE] - [y\,dF] - \overline{dE}[x] - \overline{dF}[y] &= w_R \\ [dE] &= 0 \\ [dF] &= 0 \end{aligned}$$

for the height adjustment. But if we put

$$\begin{aligned} w_P + \overline{de}[x] + df[y] &= w'_P \\ w_Q - \overline{de}[y] + df[x] &= w'_Q \\ w_R + [z\Delta K] + \overline{dE}[x] + dF[y] &= w'_R \end{aligned} \tag{3n}$$

the final condition equations will be:

$$\begin{aligned} -[x\,de] - [y\,df] &= w'_P \\ [y\,de] - [x\,df] &= w'_Q \\ [de] &= 0 \\ [df] &= 0 \end{aligned} \tag{3o}$$

for the horizontal adjustment, and

$$\begin{aligned} -[x\,dE] - [y\,dF] &= w'_R \\ [dE] &= 0 \\ [dF] &= 0 \end{aligned} \tag{3p}$$

for the height adjustment. If we designate C_1, C_2, C_3 and C_4 as the correlative factors for the horizontal adjustment and C_1, C_2 and C_3 as the correlative factors for the height

adjustment, we can write the correlative equations as follows:

$$
\begin{aligned}
de_3 &= -x_3C_1 + y_3C_2 + C_3 \\
de_4 &= -x_4C_1 + y_4C_2 + C_3 \\
&\cdots\cdots\cdots\cdots \\
&\cdots\cdots\cdots\cdots \\
df_3 &= -y_3C_1 - x_3C_2 + C_4 \qquad (3q) \\
df_4 &= -y_4C_1 - x_4C_2 + C_4 \\
&\cdots\cdots\cdots\cdots \\
&\cdots\cdots\cdots\cdots
\end{aligned}
$$

$$
\begin{aligned}
dE_4 &= -x_4C_1' + C_3' \\
dE_4 &= -x_4C_1' + C_3' \\
&\cdots\cdots\cdots\cdots \\
&\cdots\cdots\cdots\cdots \qquad (3r) \\
dF_4 &= -y_4C_1' + C_4' \\
dF_4 &= -y_4C_1' + C_4' \\
&\cdots\cdots\cdots\cdots \\
&\cdots\cdots\cdots\cdots
\end{aligned}
$$

Now, as

$$[de] = [df] = [dE] = [dF] = 0,$$

we can add each group of the above expressions for the $(n-2)$ stereomodels, and write the following results:

$$(n-2)C_3 - C_1[x] + C_2[y] = 0 \qquad (n-2)C_2' - C_1'[x] = 0$$
$$(n-2)C_4 - C_1[y] - C_2[x] = 0 \qquad (n-2)C_3' - C_1'[y] = 0$$

Hence

$$
\begin{aligned}
C_3 &= C_1[x]/(n-2) - C_2[y]/(n-2) \\
C_4 &= C_1[y]/(n-2) + C_2[x]/(n-2) \\
C_2' &= C_1'[x]/(n-2) \\
C_3' &= C_1'[y]/(n-2)
\end{aligned}
$$

If we introduce these values in $(3q)$ and $(3r)$, and we put

$$
\begin{aligned}
x_i - [x]/(n-2) &= a_i \\
y_i - [y]/(n-2) &= b_i
\end{aligned}
\qquad (3s)
$$

the correlative equations will read as follows:

$$
\begin{aligned}
de_3 &= -a_3C_1 + b_3C_2 & dE_3 &= -a_3C_1' \\
de_4 &= -a_4C_1 + b_4C_2 & dE_4 &= -a_4C_1' \\
&\cdots\cdots\cdots\cdots & &\cdots\cdots\cdots\cdots \\
&\cdots\cdots\cdots\cdots & &\cdots\cdots\cdots\cdots \\
df_3 &= -b_3C_1 - a_3C_2 \qquad (3t) & dF_3 &= -b_3C_1' \qquad (3u) \\
df_4 &= -b_4C_1 - a_4C_2 & dF_4 &= -b_4C_1' \\
&\cdots\cdots\cdots\cdots & &\cdots\cdots\cdots\cdots \\
&\cdots\cdots\cdots\cdots & &\cdots\cdots\cdots\cdots
\end{aligned}
$$

Then the normal equations will be:

$$
\begin{aligned}
\left[a_i^2 + b_i^2\right]_3^{n-1} C_1 &= -w_P' \\
\left[a_i^2 + b_i^2\right]_3^{n-1} C_3 &= -w_Q'
\end{aligned}
\qquad (3v)
$$

for the horizontal adjustment, and

$$\left[a_i^2 + b_i^2\right]_3^{n-1} C_1' = -w_R' \qquad (3x)$$

for the height adjustment. Expressions $(3v)$ and $(3x)$ show how amazing is the final simplification. Indeed, as all the correlative factors are obtained in the same manner, we solve a simple equation of the form $ax = b$, and the coefficient is the same for the three correlative factors.

Form 3-I shows a complete solution for the horizontal adjustment, and form 3-II shows the height adjustment. The formulas to be used for the computation of Δe and Δf and the successive computation of e, f, P and Q are given on the bottom of form 3-I, and those used to find the values of ΔK, ΔE and ΔF and the successive values of R are shown on the bottom of form 3-II. As the height adjustment follows the horizontal adjustment the values of K can be derived from expression $(2b)$ which gives

$$K = \sqrt{e^2 + f^2}\ *$$

where e and f are taken from form 3-I. But it is also seen in form 3-II that values of K' are found in the same way as those seen in form 2-II, where a footnote explains the reason for its use.

4. Conclusion

We think that the practical example worked in the previous section is sufficient to show how to achieve an easy least square adjustment of a strip if the simplification introduced is used. However, if one or more control points are known along the strip, the problem becomes more complicated. It is possible, though, to combine the least square adjustment with some kind of graphical adjustment which will take into account the above-mentioned control points. This method is used in the Netherlands, and is described in the Belgian review "Photogrammétrie" (No. 41-1955), in an article by D. Lesne and F. Peeters.

In a very recent pamphlet published by the "Deutsche Geodätische Kommission" a highly interesting work by Hans Bertram (died 1945) was presented by Prof. Dr.-Ing. habil Rudolf Förstner. In this paper "Beitrag zur Ausgleichung räumlicher Polygonzüge bie der Luftbildtriangulation" (1963), a least square method of adjustment is derived in which the variables are exactly the same as those adopted in the Belgian method. The main difference between these two methods is that in the Belgian method the ground coordinates are computed directly in terms of the adjusted transformation elements whereas in Bertram's method the ground coordinates are computed in terms of the machine coordinates after their correction. The Bertram procedure allows an important simplification in the solution of the normal equations. In fact these formulas are similar to our $(3v)$ and $(3x)$.

Bertram's paper shows diagrams of the curves of absolute errors in x, y and z; these curves are, as usual, irregular. This irregularity is a consequence of the accidental errors in the relative orientation and of the double accumulation of these errors in the bridging process. Thus it is possible to draw a useful conclusion which is valid for every method where control points

* Barlow's tables can be used to compute K.

Form 3-I

Pair		x y	$a_1 = x - x_0$ $b_1 = y - y_0$	$10^6\, aC_1$ $10^6\, bC_1$	$10^6\, bC_2$ $-10^6\, aC_2$	$\Delta e 10^6$ $\Delta f 10^6$	e f	$-x\Delta e$ $-y\Delta e$	$-y\Delta f$ $x\Delta f$	P Q
1/2		—	—	—	—	—	−0.672741	—	—	71 393.61
		—	—	—	—	—	+0.433479	—	—	205 924.57
2/3	N_2	4 481.30	−11 489.32	−434	+ 2	− 809	−0.673550	+ 3.63	+ 0.69	71 397.93
		− 3 576.00	− 189.38	− 7	−112	+ 192	+0.433671	− 2.89	+ 0.86	205 922.55
3/4	N_3	6 889.10	− 9 081.52	−343	+ 1	− 719	−0.674269	+ 4.95	+ 0.76	71 403.64
		− 3 472.30	− 85.68	− 3	− 88	+ 220	+0.433891	− 2.49	+ 1.52	205 921.58
4/5	N_4	9 145.40	− 6 825.22	−258	− 0	− 635	−0.674904	+ 5.81	+ 0.83	71 410.28
		− 3 384.10	+ 2.52	+ 0	− 67	+ 244	+0.434135	− 2.14	+ 2.23	205 921.67
5/6	N_5	11 474.90	− 4 495.72	−170	+ 1	− 546	−0.675450	+ 6.27	+ 0.92	71 417.47
		− 3 532.50	− 145.88	− 5	− 44	+ 262	+0.434397	− 1.93	+ 3.01	205 922.75
6/7	N_6	13 614.20	− 2 356.42	− 89	− 0	− 466	−0.675916	+ 6.34	+ 0.97	71 424.78
		− 3 358.10	+ 28.52	+ 1	− 23	+ 289	+0.434686	− 1.56	+ 3.93	205 925.12
7/8	N_7	15 852.40	− 118.22	− 4	+ 1	− 380	−0.676296	+ 6.02	+ 1.07	71 431.87
		− 3 498.00	− 111.38	− 4	− 1	+ 306	+0.434992	− 1.33	+ 4.85	205 928.64
8/9	N_8	18 494.30	+ 2 523.68	+ 95	− 1	− 283	−0.676579	+ 5.23	+ 1.11	71 438.21
		− 3 277.40	+ 109.22	+ 4	+ 25	+ 340	+0.435332	− 0.93	+ 6.29	205 934.00
9/10	N_9	20 497.40	+ 4 526.78	+171	− 0	− 206	−0.676785	+ 4.22	+ 1.18	71 443.61
		− 3 323.00	+ 63.62	+ 2	+ 44	+ 357	+0.435689	− 0.68	+ 7.32	205 940.64
10/11	N_{10}	22 778.10	+ 6 807.48	+257	− 5	− 125	−0.676910	+ 2.85	+ 1.13	71 447.59
		− 2 854.90	+ 531.72	+ 20	+ 66	+ 397	+0.436086	− 0.35	+ 9.04	205 949.33
11/12	N_{11}	24 967.70	+ 8 997.08	+340	+ 0	− 37	−0.676947	+ 0.92	− 1.36	71 449.87
		− 3 407.60	− 20.98	− 1	+ 88	+ 398	+0.436484	− 0.12	+ 9.94	205 959.15
12/13	N_{12}	27 482.10	+11 511.48	+435	+ 1	+ 59	−0.676888	− 1.62	+ 1.48	71 449.73
		− 3 569.00	− 182.38	− 7	+112	+ 416	+0.436900	+ 0.21	+11.43	205 970.79
$\Sigma = (n-2)\, x_0$		175 676.90	− 0.08	0	0	−4 147		+44.62	+11.50	+ 56.12
$\Sigma = (n-2)\, y_0$		−37 252.90	− 0.08	0	0	+3 421		−14.21	+60.42	46.21
	x_0	+15 970.62								
	y_0	− 3 386.62								

$e_{(n-1),n} = -0.676885$ $\quad f_{(n-1),n} = +0.436896$ $\quad P_{(n-1),n} = 71\,449.77$ $\quad Q_{(n-1),n} = 205\,970.78$

$-e_{12} = +0.672741$ $\quad -f_{12} = -0.433479$ $\quad -P_{12} = -71\,393.61$ $\quad -Q_{12} = -205\,924.58$

$w_e = -0.004144$ $\quad w_f = +0.003417$ $\quad \overline{de}\,[x] = -66.23$ $\quad \overline{de}\,[y] = +14.04$

$\overline{df}\,[y] = -11.59$ $\quad -\overline{df}\,[x] = -54.64$

$\overline{de} = \dfrac{w_e}{n-2} = -0.000377$ $\quad \overline{df} = \dfrac{w_f}{n-2} = +0.000311$ $\quad w'_P = -21.66$ $\quad w'_Q = +5.60$

$\Sigma\,(a_i^2 + b_i^2) = 573\,913\,097.40$ $\quad C_1 = \dfrac{-10^6\, w'_P}{\Sigma\,(a_i^2 + b_i^2)} = +0.03774$ $\quad C_2 = \dfrac{-10^6\, w'_Q}{(a_i^2 + b_i^2)} = -0.00975$

Formulas: $\Delta e_i = a_i C_1 + b_i C_2 + \overline{de}$; $\quad e_{i,(i+1)} = e_{(i-1),i} + \Delta e_i$; $\quad P_{i,(i+1)} = P_{(i-1),i} - x_i \Delta e_i - y_1 \Delta f_i$

$\Delta f_i = b_i C_1 + a_i C_2 + \overline{df}$; $\quad f_{i,(i+1)} = f_{(i-1),i} + \Delta f_i$; $\quad Q_{i,(i+1)} = Q_{(i-1),i} - y_i \Delta e_i + x_i \Delta f_i$

Form 3-II

Pair	K^2	K	K'	$\Delta K'$	z	$10^6 K\delta\varphi$	$10^6 a C_1'$	$10^6 \Delta E$	$10^6 E$	$10^6 b C_1'$	$10^6 \Delta F$	$10^6 F$	$-\Delta K' z$	$-\Delta Ex$	$-\Delta Fy$	R
1/2	0.64048449	0.800303	1.000378	−981	511.0	− 8 676	−89	− 7 759	+ 80	−1	+139	− 185	+0.50	+ 34.77	+0.50	− 0.92
2/3	0.64174014	0.801087	1.001359	−904	543.3	+ 9 904	−71	+10 839	−7 679	−1	+139	− 46	+0.49	− 74.67	+0.48	+ 34.85
3/4	0.64290008	0.801810	1.002263	−833	552.5	− 7 620	−53	− 6 667	+3 160	0	+140	+ 93	+0.46	+ 60.97	+0.47	− 38.85
4/5	0.64396861	0.802477	1.003096	−750	577.0	+ 2 583	−35	+ 3 554	−3 507	−1	+139	+ 233	+0.43	− 40.78	+0.49	+ 23.05
5/6	0.64493346	0.803077	1.003846	−688	591.7	+ 3 468	−18	+ 4 456	+ 47	0	+140	+ 372	+0.41	− 60.66	+0.47	− 16.81
6/7	0.64581436	0.803627	1.004534	−604	657.8	−11 007	− 1	−10 002	+4 503	−1	+139	+ 512	+0.39	+158.56	+0.49	− 76.59
7/8	0.64659432	0.804111	1.005138	−523	636.7	+ 1 704	+19	+ 2 729	−5 499	+1	+141	+ 651	+0.33	− 50.47	+0.46	+ 82.85
8/9	0.64727309	0.804533	1.005666	−458	680.2	− 6 319	+35	− 5 278	−2 770	0	+140	+ 792	+0.31	+108.19	+0.47	+ 33.17
9/10	0.64786284	0.804899	1.006124	−400	731.5	+ 8 093	+53	+ 9 152	−8 048	+4	+144	+ 932	+0.29	−208.47	+0.41	+142.14
10/11	0.64837815	0.805219	1.006524	−309	734.7	+ 4 426	+70	+ 5 502	+1 104	0	+140	+1 076	+0.23	−137.37	+0.48	− 65.63
11/12	0.64877552	0.805466	1.006833	−213	694.0	− 8 352	+90	− 7 256	+6 606	−1	+139	+1 216	+0.15	+199.41	+0.50	−202.29
12/13	0.64905141	0.805637	1.007046						650			+1 355				2.23
Σ						−11.796	0	− 730		0	1 540		+3.99	− 10.52	+5.22	

$E_{(n-1),n} = -0.000646$
$-E_{12} = -0.000080$
$-[K\delta\varphi] = +0.011796$
$w_E = +0.011070$

$\overline{dE} = \dfrac{w_E}{n-2} = +0.001006$

$F_{(n-1),n} = +0.001357$
$-F_{12} = +0.000185$
$w_F = +0.001542$

$\overline{dF} = \dfrac{w_F}{n-2} = +0.000140$

$R_{(n-1),n} = -2.28$
$-R_{12} = 0.92$
$dE\,[x] = 176.73$
$[x\,K\delta\varphi] = -170.66$
$dF\,[y] = -5.22$
$[z\,\Delta K'] = -3.99$
$w_r' = -4.50$

Formulas: $\Delta E_i = \overline{dE} + K\delta\varphi_i + a_i C_1'$; $\Delta F_i = \overline{dF} + b_i C_1'$; $E_{i,(i+1)} = E_{(i-1),i} + \Delta E_i$; $F_{i,(i+1)} = F_{i,(i-1),i} + \Delta F_i$
$R_{i,(i+1)} = R_{(i-1),i} - \Delta K_i' z_i - \Delta E_i x - \Delta F_i y_i$; $C_1' = -w_r' + \Sigma(a^2 + b^2) = +0.0078 \times 10^{-6}$.

exist only on the end stereo-pairs: the best results will be obtained if the relative orientation procedure is sufficiently accurate. Numerical orientation would be advisable.

We have adapted the method to be used for the adjustment of strips in closed circuits without jeopardizing the simplicity.

We feel that in the near future analytical aerial-triangulation will be almost generalized but that this will not eliminate the universal plotters, which have a very long life-span. Thus, wherever these instruments are at present in existence in an organization, their use will be continued. Therefore, we think the adjustment method described here will be serviceable for some years to come.

RAPID MAPPING OF VAST AND INCOMPLETELY EXPLORED TERRITORIES ON SCALES OF 1:100,000-1:300,000[1]

Abstract

Considerable speeding-up of work involved in mapping vast incompletely explored territories on the scales 1:100,000-1:300,000 can be measured by methods of aerial surveying with one-lens wide-angle cameras (84°-136°). Horizontal and vertical control is to be obtained with the help of airborne radio distance-measuring equipment, radioaltimeter and statoscope Aerial cameras type AFA-TE, 18 × 18 cm. with focal lengths 55, 70, 100 and 140 mm., gyrostabilizing system type N-55, radiogeodetic stations type RGSZ, radioaltimeter type RVTD-A, and statoscope type S-51 are recommended for use. Three possible solutions of the problem relating to the mapping of flat, mountainous and alpine regions respectively, are discussed in some detail. The technique described is only tentative, and may be modified in accordance with the conditions of work in every particular case. The main advantage consists in the possibility of obtaining detailed and accurate maps more rapidly and reducing labour and costs.

A method of the rapid mapping, on the scales of 1:100,000-1:300,000 of vast and incompletely explored territories lacking adequate cartographical date is discussed in this paper.

Maps on the scales of 1:100,000-1:300,000 can be used for the general study of the earth surface. The purpose of such maps is to facilitate geological surveys, inventories of large forested areas, the preliminary calculations involved in planning populated centres and big buildings, road reconnaissance, etc.

A map on either of these scales must contain: coastline of seas, rivers and lakes, all populated areas, industrial and agricultural plants and buildings, railways, roads of all kinds, paths, communication lines, boundaries, forests with their corresponding classification, shrubs, arable land, meadows, steppes, rock outcrops, deserts, mountain glaciers, etc. Terrain relief should be shown by contours; contours are to be drawn at 20, 50, or 100 m. intervals depending on accuracy requirements, and with mean errors not exceeding half the contour interval.

The maps should be produced by methods that will make it possible to speed up the work and reduce the time, labour and cost involved to a minimum. This end can be attained only if the method of aerial survey is applied with the simultaneous utilization of airborne electronic distance-measuring equipment, radioaltimeter and statoscope to obtain horizontal and vertical control.

Aerial photography should be carried out with one-lens wide-angle aerial cameras (84°-136°) at a horizontal position of the plane of the aerial picture. This permits a considerable simplification of subsequent photogrammetric plotting, gives a possibility of using eventually the same photographs (with additional geodetic control) for producing maps of larger scales, and improving the quality of photo-interpretation. (It should be noted that the area covered by a single wide-angle photograph is not less than that covered when a multi-lens aerial camera is employed.) To obtain subsequent photo-interpretation, besides the main aerial camera the aircraft should be equipped with other cameras to take colour, spectrozonal of infrachromatic photographs, and also photographs on a larger scale or oblique aerial pictures. The most convenient for use the aerial cameras type AFA-TE, 18 × 18 cm, with focal lengths 55, 70, 100 and 140 mm.

Horizontal control is obtained with the help of airborne radio distance-measurement equipment based on the principle of radio ballon, or radio log. When working according to the radio log principle, two ground (reflecting) stations are placed on the terrain at a distance 80-120 km. between them, while the airborne master station is installed on the surveying aircraft and continually transmits radiowaves of a determined frequency. These transmitted waves are received by the slave stations, are transformed in ratio 2/3 (the first slave) and 3/2 (the second slave), and retransmitted. After the retransmitted radiowaves have been received by the airborne station, a phase comparison is made with the waves, that have been transmitted by the airborne master station; any phase-difference corresponds to a change of distance from the master slave station. Therefore, radiogeodetic measurements make it possible to determine any change of distance from the aircraft to any one of the ground stations. If the co-ordinates of ground stations and those of the initial positions of the aircraft are known, then, utilizing the results of radiogeodetic measurements it is possible to determine the distances from the ground stations to any position of the aircraft and to calculate the co-ordinates of the latter. To determine plane co-ordinates of the initial position of the aircraft, the two first aerial photographs are taken over an area provided with geodetic points: this gives a possibility of finding the co-ordinates of nadir points of a photograph that coincide with the plane co-ordinates of the perspective centre.

[1] The original text of this paper, contributed by the Union of Soviet Socialist Republics, appeared as document E/CN.14/CART/95.

The existing equipment (RGSZ) gives a possibility of determining plane co-ordinates of perspective centres at distances from the aircraft to ground stations about 200-220 km.; thus, at any one setting of the ground stations an area about 40,000 km.^{2} is photographed. The mean error of aircraft co-ordinates is about $\pm$ 8 m; this gives a possibility of compiling topographical maps even on a 1:25,000 scale. Therefore, when maps 1:100,000-1:300,000 are being compiled, it is possible to obtain the length of the base between reflecting stations from radiogeodetic measurements, it is not obligatory that the stations should be set up only at places of known geodetic co-ordinates; instead of determining plane co-ordinates of several points on the initial (first) stereo-pair, co-ordinates of only one point may be determined. Besides that, nadir points of aerial photographs, the plane co-ordinates of which were obtained from radio distance-measurements, may be used as control points for aerial surveying of an adjacent territory. Thus, if radiogeodetic stations RGSZ are used, it is possible to proceed with only 4-5 astronomical points over an area of about 100,000 km^2.

To establish the height control the method of radiolevelling should be adopted; this method is based on the combined use of a radialtimeter and a statoscope. The radialtimeter type RVTD-A is an airborne distance-measuring system that sends out pulses of a certain frequency towards the ground. The radiowaves that are reflected from the ground stations installed at points which are nearest to the aircraft, will return back to the master station in the shortest time, and in this way it will be possible to determine the shortest distance from the aircraft to the ground. With the help of special stereoscopic grids, this measured distance can be transformed to get the flight-height of the aircraft over a horizontal plane passing through the nadir point of an aerial photograph. The statoscope which is a differential siphon-barometer serves to determine changes in flight-height of the aircraft. The readings of the radialtimeter and statoscope (along with those of the radio distance-measuring instrument) are registered by special photorecording devices, which are actuated simultaneously with the releasing of the aerial camera shutter. These data permit the calculation of differences in elevations of all the nadir points in relation to one of them considered as the initial one; the mean error of determination of height difference of two adjacent nadir-points is about $\pm$ 1.5 m.

Executing of photogrammetric work is considerably complicated in the cases where the aerial photographs have large and unknown angles of tilt. Reduction of the plane of a photograph to a horizontal position is effected by means of a gyrostabilizing device type N-55 which ensures that aerial photographs will be obtained with a mean deviation from the prescribed position equal to form $\pm$ 12 to 15 m.

Thus, it is recommended to map incompletely explored territories on scales from 1:100,000 to 1:300,000, by an aerial survey method using aerial cameras type AFA-TE, 18 $\times$ 18 cm., focal lengths 55, 70, 100 and 140 mm., with gyrostabilizing equipment type N-55, radiogeodetic stations type RGSZ, and statoscope type S-51.

In mapping incompletely explored regions on scales 1:100,000 to 1:300,000, various technical solutions present themselves in accordance with the physical-geographical conditions of the area to be mapped and, in the first place, with the type of relief. Three fundamental solutions may be proposed—for flat, mountainous, and alpine regions respectively. We shall consider here as flat regions areas with elevation differences within a single photograph not exceeding 150-200 m; as mountainous, areas with elevation differences within a single photograph not exceeding 1,000 m., and characterized by rounded smoothed-out summits; and as alpine, regions are considered high-mountain areas with great elevation differences. It is self-evident that very substantial changes may be introduced into these solutions to meet requirements of every specific case in practice.

Flat regions. Aerial surveying is to be done with an aerial camera AFA-TE, focal length 55 or 70 mm., at scales 1:60,000-1:80,000, with longitudinal overlap 80%, and side overlap 30%. A second aerial camera, focal length 100 mm., is installed on board the aircraft, which will make it possible to get larger-scale photographs needed for interpretation. The main camera is mounted in a gyrostabilizing system. If both the cameras work in synchronism, the longitudinal overlap of photographs taken with the second camera is 60%, but in transversal direction gaps 1-3 km. wide may occur. In addition to coverage of the whole area with such strips each of 60-80 km., control strips on the same scale are flown perpendicularly to them with a longitudinal overlap of 90%. Control strips are spaced 60-80 km. apart, i.e. they are placed along the boundaries of the main strips.

Readings of the radialtimeter and statoscope are to be taken on all strips; readings of the radio distance-measuring instrument are photographed only along control strips and also along some longitudinal strips spaced at intervals 60-80 km. which may therefore be considered as being longitudinal control strips. When flying control strips, all flights should begin and end over such areas that are provided with points of known geodetic co-ordinates. If the ground stations are not located at points for which geodetic co-ordinates are known, then it is necessary to execute flights along a base line as well.

Field geodetic and topographic work is undertaken with the aim of establishing the necessary horizontal and height vertical control, and so to ensure the possibility of photo-interpretation. Along with photo-interpretation, all nececessary information regarding place names (of localities, rivers, etc.), the boundaries of administrative divisions, specific geographical features, etc. should be collected.

Horizontal control is established in the form of astro-points observed at intervals of 100-150 km. Vertical control must be provided with geodetic spot-heights, the stereopairs of control strips, at intervals of 60-80 km; for this purpose, elevations of four points lying approximately at the four angles of a stereopair should be determined. To get spot-heights, altitude traverses are run using available levelling marks. Barometric levelling may be used for this purpose, as also the data on water-level of rivers. If there is no geodetic vertical control available in the area, a number of aerial photographic traverses should be run and readings of the radialtimeter and statoscope should be recorded.

Data needed for photo-interpretation are collected

mainly in localities; in addition, special field interpretation strips should be run, the number and direction of which are decided upon after a preliminary study of the results of the aerial survey. The strips are run along main roads and through populated areas. In the process of field work, keys for subsequent office interpretation of the vegetation cover must be compiled. In some cases visual observations from an aircraft will prove necessary as an aid to photo-interpretation.

Office programmatic work consists in establishing the horizontal and vertical control of the map, executing the photo-interpretation of aerial photographs and plotting a compilation base. In the first place, an analysis of the radio distance-measuring instrument readings and the readings of the radialtimeter and statoscope, as well as a determination of elements of relative orientation of aerial photographs are carried out; then, on the base of all these data, radiogeodetic polygons are established and adjusted; subsequent calculation done with an electronic computer lead to the determination of plane co-ordinates of perspective centres of photographs contained in control strips. With these photographs a spatial photogrammetric net is plotted twice (once using the even, and then—the odd photographs) on a 12-projector multiplex. Following the net compensation, the plane co-ordinates and elevations of points photographed on all remaining strips are found. Then aerial photographs of all remaining strips that are connected with points determined during the plotting of control strips are analysed in the same way. In the process of plotting nets on the multiplex, all spot-heights and horizontal positions of points needed for compilation of a photoplan are obtained.

Office photo-interpretation consists in stereoscopic observation of large-scale photographs taken with an additional aerial camera; if there are gaps between adjacent strips, then photographs taken with the main camera are used. In office photo-interpretation, keys and data obtained by field interpretation and all available sources of information are utilized. Relief is shown in contours with the help of a stereoscope, making use of points, the elevations of which were determined by photo-grammetry. The map original is obtained in the form of a photo-plan to which the contours and results of photo-interpretation are transferred.

Mountain regions. Aerial survey is executed with an aerial camera of 70 mm. focal distance, with an overlap $80 \times 50\%$. A second aerial camera has the focal distance 140 mm. Besides that, in certain cases a third aerial camera may prove necessary for taking oblique photography. Strips are flown in the same order as in flat country, but because of an insufficient number of readings of the altimeter (owing to unfavourable conditions of radio-wave-reflection) additional transversal control strips are run at intervals of 30 km., at a height of 1,500-2,000 m.

Field geodetic work remains the same as in flat country. Office photogrammetry (horizontal and vertical control extension, and photo-interpretation) does not undergo any change.

Compilation is done on a 3-projector multiplex using points, the co-ordinates of which were obtained from photogrammetric control extension.

Alpine regions. Mapping of alpine regions is considerably complicated, mainly due to the necessity of providing supplementary field vertical control, because in these regions frequent gaps in altimeter readings may be expected even in cases where the aircraft is flying at a low altitude. Aerial photography is to be taken with an aerial camera of 70 mm. focal distance on a 1:150,000-1:200,000 scale, with $80 \times 40\%$ overlap. Two additional aerial cameras of focal length 140 mm. should be installed on board the aircraft: one of them is intended for vertical photography, and the other—for oblique photography. Transversal control strips are flown on the same scale at 100 km. intervals. Besides that, to ensure a possibility of photo-interpretation of valleys, flights about 3,000 m. should be carried out along the thalwegs and the valleys are photographed with an aerial camera of 140 mm. focal length, with 60% overlap. During all flights excepting those executed for valleys, interpretation, readings of the statoscope, radialtimeter, and radio distance-measuring instrument are to be recorded.

Horizontal geodetic control remains the same as when work is done in flat regions. To obtain vertical geodetic control, three points on each stereopair of the control strip should be determined.

During office work, positions of nadir points are determined from measured angles of tilt of aerial photographs contained in the control and in some other strips; radiogeodetic nets are established and compensated, and plane co-ordinates of nadir points of all photographs are calculated. Spatial photogrammetric nets are plotted twice, using control strips on a 12-projector multiplex for which the utilization of plane co-ordinates of nadir points and of the statoscope and radialtimeter readings is obligatory. The points, the co-ordinates of which were obtained from the plotting of control strips, as also the plane co-ordinates of all points of photography, are used for multiplex-plotting of spatial photogrammetric nets from photographs of all the remaining strips. In office photo-interpretation vertical and oblique large-scale photographs are utilized along with aerial photographs taken during special flights over thalwegs of valleys; gaps are interpreted from small-scale photographs. The map is compiled on a 3-projector multiplex under obligatory accounting for earth curvature, as its effect will be great in small-scale photography.

The technique described is to be regarded as tentative, and may undergo considerable changes in accordance with actual conditions of work in every individual region. The main advantage of this technique is that it reduced to a minimum the labour-consuming and costly topographic and geodetic field operations, and substitutes office work for them, at the same time ensuring a possibility of obtaining sufficiently detailed and accurate maps.

AERIAL SURVEY IN NIGERIA: AN APPLICATION OF NEW TECHNIQUES[1]

INTRODUCTION

Reliable maps are one of the most important prerequisites of economic development and progress. The natural resources must first be mapped before they can be put to the services of man.

The need for mapping is particularly urgent in developing countries where the governments are striving to accelerate greatly the rate of development in order to raise the living standards of the people.

Aerial photogrammetry can provide the answer to this requirement for rapid mapping. However, many of these developing areas pose serious problems even to photogrammetric methods.

The first step in a mapping programme is to obtain good quality aerial photographs at an economical scale. Unfortunately, most of these areas requiring mapping are very difficult to photograph because of poor weather and dense forests.

The establishing of needed ground control for aerial mapping is costly and time-consuming in areas of difficult access: in mountainous terrain or areas covered with rain forests. Therefore, a new system of instruments has been assembled, integrating the aerial camera with several auxiliary instruments. This reduces the amount of ground control needed. It may ultimately permit mapping from aerial photos without surveys on the ground.

In the mapping programme for Nigeria, two problems confronted us:

(*a*) In the aerial photographic phase we met adverse weather conditions, Harmattan haze and few maps for navigation;

(*b*) In the ground survey phase, difficult access and high cost of ground control.

This project included an area which had not been photographed successfully during numerous attempts over the past 10 years. Clouds form early in the morning at 3,000 to 6,000 feet and persist throughout the day. On days when northern winds blow, the clouds are driven out to sea then they are replaced by Harmattan haze.

To overcome these problems we sought new solutions. We brought together a number of technological advances in photogrammetry, navigational techniques and ground surveys. The progress of the Nigerian mapping project established that difficult areas now can be mapped economically, employing advanced but simple techniques.

This Nigerian mapping programme was sponsored by the Government of Canada under the Special Commonwealth Africa Aid Programme. The initial contract, awarded in the fall of 1961, included aerial photography, ground control surveys, photogrammetric compilation and five colour separation scribing to provide topographical maps at a scale of 1:50,000 with 50-foot contour intervals for 28,400 square miles in Central and Western Nigeria. This contract was extended in December 1962 to provide aerial photography of 30,600 square miles and topographical mapping of 8,600 square miles. In addition, it included an airborne magnetometer survey of 13,000 line miles at 1/4-mile spacing of three areas in Nigeria.

PLANNING OF THE PROJECT AND INSTRUMENTATION EMPLOYED

From a study of available meteorological data we concluded that very often the heavy layer of Harmattan haze is concentrated at an altitude of 12,000 feet. This suggested that photography could be obtained from an altitude lower than 12,000 feet in spite of this haze. Our experience some years ago in Liberia with panchromatic and infra-red photography showed clearly that infra-red photography is superior to panchromatic in tropical areas. This conclusion has been confirmed in our project in Nigeria, as well as on a 1,000-km. railroad survey in Gabon. The infra-red film yields penetration through haze, increased differentiation in vegetative coverage, and higher contrasts between land and water.

Considering these factors, we decided to employ a Wild RC-9 camera equipped with Super-Infragon lens and infra-red film. This Super-Infragin lens is corrected for the infra-red spectrum. The Superwide angle camera allowed us to obtain photography at a scale of 1:40,000 from an altitude of 11,600 feet, so we were able to fly just below the heavy layer of Harmattan haze. Thus, the major obstacle to an economic scale of photography under Harmattan conditions had been overcome.

The lack of suitable maps for navigation demanded the use of electronic navigational aids. Without such aids, the percentage of reflights because of gaps in photo coverage might have been considerable. We decided to employ the Radan-Doppler navigational system. The Radan navigation system controls flight in a predetermined direction, the overlap between flight lines, and the fixed distance between exposures. This ensures accurate navigation and correct scaling of each stereo-model without reference to ground control.

Radan navigation equipment uses the Doppler principle. The system includes a course and distance computer, a Kearfott J-4 compass, and a specially designed computer to track the aircraft on a set course. It provides the aircraft's position continuously and is free of ground stations.

Four beams or pencils of radiation are directed downward from the aircraft. Two are transmitted forward and two aft in an X-shaped pattern. These pulses are reflected from the ground back to the aircraft, and frequency changes are measured. Drift angle and ground speed are computed from these frequency changes. The data from the Doppler are computed and presented visually to the pilot instantly. At the beginning of the first flight line of each mission, two parameters, line length and magnetic azimuth, are set in the Doppler system's computer, which then begins to indicate deviations left or right of track and counts elapsed mileage on a visual indicator. During the flight of each line, the parameters of the next line are

[1] The original text of this paper, submitted by Nigeria, appeared as document E/CN.14/CART/98.

introduced into a second circuit of the computer. These are line length, magnetic azimuth, and offset (line spacing).

To reduce the extent and consequently the cost of ground surveys we have employed several auxiliary instruments in conjunction with the aerial camera. These instruments give the orientation of the aerial camera at the moment of exposure. A Wild Horizon camera and Statoscope were used. The Horizon camera photographs the horizon in four directions (forward, aft, left and right) on 35 mm. film. The relative tip and tilt are determined from measurements made on the horizon pictures. This new Wild Horizon camera is in the same mount as the RC-9 camera. A parallellogram linkage system between the RC-9 and the Horizon camera assures that the swing of both cameras is identical at all times. The horizon pictures are synchronized with the vertical photographs.

The first Horizon camera was developed in Finland by Nenonen in 1928. It was built by the Zeiss Company. This camera photographed the horizon only in two directions perpendicular to each other. It did not find much practical application outside of Finland and was almost forgotten by the end of the Second World War. In 1960, a new Horizon camera, designed by Lofstrom and built by the Wild Company, became available.

The Statoscope registers the difference in elevation between each exposure station relative to a barometric pressure reference. The indications of the Statoscope are registered directly on the $9'' \times 9''$ negatives.

In summary, the equipment installed in our DC-3 aircraft included the following:

(*a*) Wild RC-9 aerial camera equipped with Super-Infragon lens;

(*b*) Radan-Doppler navigational system;

(*c*) Wild Horizon camera;

(*d*) Statoscope.

These instruments have been used separately before. This project was the first time that they were integrated as a mapping system. The scope and the difficulties of the Nigerian project warranted the cost of assembling this system.

To take full advantage of the auxiliary data provided by the system, the aerial triangulation had to be approached in a new manner. We had the choice of using the Wild A-9 or a Stereocomparator, or of developing new techniques using the Wild B-8.

We decided against the A-9 because it uses diapositives reduced to half size. The resulting scale of the diapositives would have been 1:80,000. Therefore, interpretation of detail would have become more difficult and reading of elevations would have become less accurate than was possible from the original 1:40,000 photographs. Errors would have occurred when identities of pass points were being transferred from the reduced diapositives to the original diapositives that were to be used on the Wild B-8 plotter for compilation.

We decided against the Stereocomparators because of their high cost compared to their limited over-all use. Because of shortcomings for our purposes in these two instruments, it was necessary to develop a new aerial triangulation method around the Wild B-8 plotter and the auxiliary information provided by the Horizon camera, the Statoscope and the Doppler system. The theoretical evaluation of the accuracies of each of the auxiliary instruments and of the B-8 plotter indicated that with the auxiliary data, accurate aerial triangulation with independent pairs could be done on the B-8 instrument.

Introduction of the auxiliary data, particularly the horizon data, into the bridging procedure, eliminated the double summation of errors. Consequently we eliminated the need for vertical control in the centre of the bridged strip. This permitted a one-third reduction in the density of the vertical ground control, compared to the amount required in the aeropolygon method of triangulation.

Aerial triangulation with Horizon camera, Doppler and Statoscope

The aerial triangulation method employs the principle of bridging with independent pairs. Since Doppler triggers the aerial camera at predetermined distances, the base between two consecutive stereograms is known and is introduced into the B-8. Therefore, the scale of each model is determined from auxiliary information and does not depend upon ground control or a photogrammetric process. The absolute orientation of the stereo-model is determined by the ψ and ω derived from the horizon pictures; hence, it is independent of any other stereo-model of the line. The vertical datum can be transferred by computing H (the flying light above a vertical datum) for each exposure with the help of Statoscope data.

The horizon pictures are measured using a Wild Stereomicroscope. It should be stressed that it is not necessary to photograph the true horizon, for any well identified line of the horizon will suffice. In Nigeria, the boundary between the heavy layer of Harmattan haze of the sky provided an excellent reference line. With the Stereomicroscope we determined the displacement of the horizon line in a given horizon picture in relation to the horizon line in the corresponding reference horizon picture. Only the relative differences in tip and tilt are determined in this way. To determine the absolute value of the tip and tilt at least one stereo-model in each flight line has to be levelled to the ground control. The absolute values for ψ and ω are computed by adding the differences $\Delta\psi$ and $\Delta\omega$ derived from the horizon pictures to the absolute value of ψ and ω determined from the ground control set-up. We provide vertical control for the first and the last model of each flight line in order to check the determination of absolute ψ and ω .

The results are considered to be correct if a closure is obtained within an accuracy equivalent to that of the absolute orientation of the model.

The instrument used for aerial triangulation is a Wild B-8 stereo-plotter. It was slightly modified, placing on the plate holders specially designed L-shaped bubbles for accurate introduction of the tip and tilt. The attachment consists of two 20-second bubbles placed on a stable mount. When placed on the plate holder the bubbles are parallel to the x and y axis of the $9'' \times 9''$ diapositives. Each bubble can be tilted in the vertical direction. A

drum is attached to the vertical screw to permit direct readings of ψ and ω to an accuracy of 1° (30 seconds).

The selection of pass points in rain forested areas and in areas without much clear planimetric detail is extremely difficult. Moreover, the transferring of pass points between flight lines can be a significant source of errors if the utmost care is not exercised. To achieve maximum accuracy in the selection and transferring of pass points on the Nigerian survey, they were pre-selected and pricked on the glass diapositives, using the Wild PUG-2 point transfer device.

The aerial triangulation by the independent pairs method can be carried out in three ways:

(*a*) The absolute values for ψ and ω are introduced on every second vertical aerial photograph.

(*b*) The absolute value for ψ and ω are introduced first on the left and then on the right aerial photograph. Then the average value for ψ and ω for the left and for the right photographs is computed from both these determinations and introduced in the plotting instrument to establish the absolute orientation of the stereo-model. This method of determining absolute orientation produces somewhat better results. Its main advantage is that it minimizes the effect of the inaccuracies of the relative orientation on the absolute orientation. The adjusting of the aerial triangulation is also simpler when this method is employed.

(*c*) When the Statoscope data are combined with the data derived from the horizon pictures and Doppler, it is possible to plot any model within a strip without the necessity of bridging the entire strip. Assuming that one model of a strip has sufficient control to determine the elements of absolute orientation, the flying height above a vertical datum of each individual aerial photograph within a strip can also be determined. The following elements of absolute orientation of each stereo-model within a strip are then known: tip and tilt determined from the Horizon camera, flying height relative to a vertical datum determined with the help of Statoscope data, and the base distance between each exposure given by Doppler, which establishes the scale. The slope of the barometric surface can be determined either by taking a number of meteorological observations during the survey flight or by having a known ground elevation at the end of the flight line and comparing the computed flying height with the one determined from the ground control.

Horizontal control

To establish the horizontal ground control, Tellurometers were employed. We used the MRA-1 and the new MRA-3 Tellurometers. The instruments have proven to be an excellent surveying tool in tropical areas as well as in the Canadian Arctic.

The longest Tellurometer traverse was along the Niger River. Monuments have been established at 1½- to 2-mile intervals. This large density of monuments was established because of the needs of the Inland Waterways Department. These monuments will serve as control for a detailed survey of the river. In addition to the Tellurometer traverse along the Niger River, we have established horizontal control located generally at the perimeters of each 1:100,000 sheet. Stereotemplate laydowns in blocks containing a minimum of two 1:100,000 sheets were made to extend the horizontal control.

Training of Nigerian personnel

The mapping programme in Nigeria included also a modest programme of training of the Nigerian personnel. One of the members of the Federal Surveys Department of Nigeria is working in our office in Ottawa and is being trained in the use of the auxiliary instruments, particularly the Horizon camera data and the new aerial triangulation methods which take advantage of the auxiliary information. A number of Nigerian surveyors and computers also have been working closely with our men in the field and in our field office in Lagos. Our experience gained on this project was shared with the members of the Federal Surveys Department in Nigeria, who contributed useful insights and a valuable knowledge of the terrain.

Summary of results and conclusions

The field operations of this project are now completed. Aerial photography at a scale of 1:40,000 of some 59,000 square miles was obtained in two flying seasons: October 1961 to April 1962, and January 1963 to April 1963.

In the field survey phase, we have completed 1,690 miles of traverses and 519 miles of levels. We established 207 bench marks. Ground control was established by field crews of Canadian Aero Service Limited and of Pathfinder Engineering Ltd. of Vancouver, who are also performing part of the map compilation.

The field survey work started in December 1961 and was completed in June 1963 employing an average of four field survey parties. The compilation of the topographical maps for 37,000 square miles is scheduled for completion by the middle of 1964.

This mapping was undertaken in response to an urgent need by Nigeria for aerial photographs and topographical maps to be used in planning for power transmission lines, roads, railways, oil and ore explorations, forest inventories and management, agricultural development, hydrological investigations, irrigation projects, and water transport development of the Niger and Benue rivers.

The aerial photographs and preliminary copies of the maps are being already put to a wide range of uses by a number of Federal and Regional Departments in Nigeria for agricultural, engineering, urban and regional planning, for the location of transmission lines, improvements of waterways, road locations and many others.

The use of the Superwide angle lens and infra-red film in Nigeria demonstrated that it is possible to obtain good quality photographs in tropical areas under adverse haze conditions. The infra-red photography is superior to the panchromatic in tropical areas because:

(*a*) It permits some penetration through haze, thus bettering the photo quality and increasing the number of photo days;

(*b*) It shows more differentiation in tropical forests than panchromatic photographs, thus improving the stereoscopic image;

(*c*) It exposes drainage in areas covered with heavy vegetation by heightened contrast between water and land.

This is of particular importance in areas where the drainage is the predominant terrain feature.

The interpretation of details on infra-red pictures may seem difficult at first because we are not accustomed to looking at this type of photography. However, this is a minor difficulty and the reluctance of the photo-interpreters is easily overcome during the first week of the project. They soon recognize that they can see more on infra-red photos than on panchromatic ones.

The results obtained to date on the Nigerian project prove that it is possible to determine from horizon pictures the tip and tilt of the aerial camera at the moment of exposure with the same order of accuracy as the accuracy of the relative orientations. The mean square errors of the elements determined from horizon pictures and based on the results obtained to date are:

$$d\psi = \pm 4^{\circ}$$
$$d\omega = \pm 6^{\circ}$$

A slightly higher error in ω is due to the instability of the B-8 plotter in the ω direction of approximately $\pm$ 2°.

The aerial triangulation can be carried out with a high degree of accuracy by employing relatively simple and inexpensive instruments, such as a Wild B-8, with auxiliary data. The mean square error in elevation triangulated with this method is $\pm$ 6.8 feet. This was computed by comparing elevations of 97 vertical control points spread throughout a test area measuring 34 by 34 miles. The length of each strip was 15 models, and vertical control was established only in the first and last model of the strip. The results achieved to date and based on bridging of same for 2,800 stereo-models show that the elevation of the pass points are accurate to within $\frac{1}{3}$ of the 50-foot contour intervals.

The accuracy of the scale determined from Doppler is such that 90 per cent of all distances are accurate to within $\pm$ .030%. This was determined from comparison of the scale derived by Doppler with the scale derived from stereo-template laydown.

The density of the vertical control is reduced by one-third as compared with the aeropolygon method of triangulation.

The ground control can be established at points where the access is best and where good photo identities can be made because there is no rigid requirement regarding the location of the ground control within a strip.

The aerial triangulation need not be carried out in strips. It is possible to bridge across the block in any direction.

The use of the Horizon camera, Doppler and Statoscope developed a new concept in vertical aerial triangulation. It is no longer necessary to bridge the entire strip in a stereoplotting instrument in order to plot a number of selected stereo-models. Any stereo-model within a strip can be plotted independently because the scale is determined from the Doppler, the tilt and tip from the Horizon camera and the vertical datum from the Statoscope. This feature is of particular significance if maps of selected areas are urgently needed for special projects. They can be compiled before a whole block of map sheets is triangulated and adjusted.

The methods employed in Nigeria can be successfully applied in other parts of the world. The infra-red photography also will produce superior results in tropical forest areas of Africa, South America, India, Pakistan or Australia. The Horizon camera can be employed in any area of the world where a readily identifiable line on the "horizon" can be photographed.

The results achieved to date indicate a broad potential for the mapping system employed in Nigeria despite its limitations. Improvements in the instrumentation and in the methods of employing auxiliary data for aerial triangulation surely can be made, and it is hoped that new developments in the system may grow out of its study and use by other photogrammetric engineers.

The office space for the project, accommodation for our personnel, transportation and help needed for the survey parties and air crews were provided by the Federal Surveys Department of Nigeria. The assistance we received from the Federal Surveys Department of Nigeria and other Government agencies is greatly appreciated. It advanced the progress of the project in many ways.

Acknowledgment is greatfully made by the author to Mr. S. G. Gamble, P.Eng., Director, Surveys and Mapping Branch, Department of Mines and Technical Surveys, Ottawa, Canada, for his encouragement and support in the development and implementation of this method.

Cadastral survey

THE APPLICATION OF PHOTOGRAMMETRY TO LAND CONSOLIDATION IN KENYA[1]

By D. E. Warren, Director of Surveys, Kenya

1. General

It was originally envisaged in Kenya that the granting of a title in the African areas would be made, subsequent to the successful carrying out of a farm plan. In 1954 it became increasingly obvious that this proposition was not realistic and a decision was made to change the order of the procedure existing at that time so that consolidation of fragments and registration of the consolidated plots received first priority.

Fragmentation existed to such an extent that modern farming could only be attempted after all the fragments

[1] The original text of this paper, submitted by Kenya, appeared as document E/CN.14/CART/5.

belonging to one owner had been consolidated into a single plot. Land Consolidation was therefore the first step in the new plan, to be followed by the registration of the consolidated plots and the issue of title. The resulting security of tenure felt by the plot owners made it much more likely that the plots would be farmed according to the plans devised by the agriculturalists.

This paper explains how maps are prepared from aerial photography to help in the consolidation and registration processes, and also to aid the Department of Agriculture in the preparation of their farm plans.

2. Outline of the procedure

For the purposes of the Land Consolidation process, the area to be consolidated is divided into well defined units averaging 3,000-4,000 acres known as sub-locations. The fragments within the sub-locations are measured by ground survey, the total area of all the fragments being checked against the area of the sub-location. After a small deduction has been made for public purposes such as schools, access roads and water holes, the consolidated plots are demarcated on the ground, and the boundaries simultaneously recorded by a plane table survey. These boundaries are subsequently traced and the prints from the resulting tracings used as interim registration index maps.

It was found that the process was greatly facilitated if an accurate area of the sub-location was known, and if the plane table sheet showed enough detail to enable the demarcator to use the detail as control. Consideration of the size of the plots after consolidation led to the conclusion that the scale of the map required should be 1:2,500, and that contours at either 10 ft. or 25 ft. V.I., dependent on the nature of the country, would help the demarcators by showing the shape of the ground. The contours are of great assistance in positioning the plots logically on the ground, so that a sensible farm plan can afterwards be devised. The maps produced by the Survey of Kenya for this purpose are colloquially known as "base maps".

It was always envisaged that the index maps, as prepared from the consolidation sheet returned to the Department by the Land Consolidation teams, would not be accurate. The two main reasons for this conclusion were:

(i) There existed a lack of technical supervision over the inexperienced personnel engaged on consolidation in the field—the consolidation procedure, highly political in nature, was the responsibility of the Provincial Administration;

(ii) The process was taking place at such a speed that any refinements of survey procedure were unacceptable to the Administration.

It was therefore decided as a matter of policy that at some future date, when the hedges which form the boundaries had grown sufficiently so as to be easily visible from the air, the areas would be reflown and more accurate maps of the registered properties would be prepared from these new air photographs. This part of the procedure is known locally as the "refly".

These more accurate cadastral maps are then compiled into new registry index maps which replace the first or interim edition in the registries.

The whole procedure can thus be tabulated as follows:

A. Breakdown of triangulation control to 4th order.

B. Production of interim registry index maps:

(i) Premarking of control;
(ii) Aerial photography at 1:25,000 scale;
(iii) Fixing of any additional ground control;
(iv) Aerial triangulation and adjustment;
(v) Plotting detail and contours at 1:5,000 scale;
(vi) Photographic enlargement of this detail to 1:2,500;
(vii) Fair drawing of base maps on regular sheet lines;
(viii) Use of base maps in the field;
(ix) Tracing of plot boundaries for interim registration index maps.

C. Production of final registration index maps:

(i) Premarking of control;
(ii) Aerial photography at 1:12,500 scale;
(iii) Fixing of any additional ground control;
(iv) Aerial triangulation and adjustment;
(v) Plotting of boundaries at 1:2,500 scale;
(vi) Ground survey of any plot boundaries missing on aerial survey;
(vii) Tracing final registration index maps and computation of final areas.

3. Details of the procedure

A. Triangulation control

Before photography takes place, every effort is made to breakdown the triangulation to 4th Order, i.e. control points are about 2-3 miles apart. The First and Second Order points are permanently beaconed with a 3'6" concrete pillar, and points of a lower order are beaconed with a 9" pyramid of concrete. Extensive use of the tellurometer is made during this triangulation breakdown. The Second Order points are adjusted by the method of least squares, whilst the direction method is used to adjust the points of lower order.

B. Production of interim registration maps

(i) *Premarking of control*

Every point is premarked with a cross having arms 15ft. long and 2ft. wide, the premarking commencing at 2ft. from the point. The premarking consists of carbide sludge sprayed on to a base of stones. Additional beaconed, unco-ordinated points in strategic and easily determinable positions are also premarked. Once the direction of the lines of flight has been determined, the control requirements for the aerial triangulation are a guide to positioning these additional points.

The importance of placing the arms of these crosses precisely at right angles is now stressed to the field staff. Instances have occurred where the irregularity of the cross has led to difficulty in determining the precise point of intersection of the arms, when undertaking the aerial triangulation.

(ii) *Aerial photography at 1:25,000 scale*

For reasons of economy, in time and money, it was decided that the maps should be plotted at 1:5,000 scale and photographically enlarged to 1:2,500 before issue to the field. It should be noted that the planimetric detail on these base maps suffers radical change when the consolidation is done, and therefore the maps have no lasting function.

The photography for the base maps is therefore taken at 1:25,000 contact scale, since the plotting is done by either a Kelsh plotter or a Nistri photo-mapper.

The photographic requirements were put out to tender and the air survey firm awarded the contract, was required to take the photography during the photographic season, January-February of each year. All the photography to date has been taken with a Wild Aviogon 6" lens. The Department has now purchased its own RC8 camera and since January 1962 has undertaken its own photography by hiring a de Havilland Heron belonging to the East African Directorate of Civil Aviation.

The film used has been in general, either:

(*a*) Ilford Hyperpan—shutter speed 1/300—aperture f 11; or

(*b*) Kodak Super XX—shutter speed 1/200—aperture f 8.

Photography has also been obtained using Ilford H.R. film and more recently poly-easter based film has been used for all photography.

(iii) *Additional ground control*

Since the aerial triangulation adjustment was in the past normally carried out by the Zarzycki method, additional co-ordinated and identified points were necessary, to conform to the minimum requirements of this method of adjustment. The density of the original control was such that generally the number of additional points required was small.

For instance, in a 200 sq. mile area of Embu District, 73 triangulation points were premarked (3 could not be identified), 19 additional points were premarked, and it proved necessary to ask for only 16 additional plan and height points and 2 additional height points. It took the surveyor only one month to complete these additional requirements.

The acquisition of an analogue computer virtually eliminated the necessity to ask for additional ground control, except for height points, on the initial overlaps of each strip, which are fixed using Wallace and Tiernan altimeters.

(iv) *Aerial triangulation and adjustemnt*

Diapositives are prepared on a logetronic printer and are then passed to the preparation section, which marks the tiepoints and principal points with the aid of a Wild P.U.G. 1 point transfer device. In terrain where photo identified points have proved difficult to see, it has also proved advantageous to mark these points using the P.U.G. 1, thereby relieving the aerial triangulator of the necessity to precisely identify the points. Care is taken to use the chisel on the P.U.G. 1 which is most suitable to the machine which will be used for plotting the detail. The scheme as prepared by this section is plotted fairly precisely on an overlap diagram of the photography, and is then passed to the analogue computer section for comment and possible amendment, before being handed over to the aerial triangulators.

The aerial triangulation is accomplished using the Wild A.7 precision autograph. Hallert's numerical method is used to achieve relative orientation since experience has proved that a better standard of triangulation, the errors being more systematic, is maintained by this method. The co-ordinate printer attached to the Wild A.7 greatly facilitates the delivery of co-ordinates to the computing section.

In the past the adjustment of the aerial triangulation was done by the Zarzycki analytical method, although for shorter strips where the discrepancies at the end of the strip were not large, a graphical adjustment usually sufficed. The strips normally consisted of 12-18 overlaps, and agreement between the points was in general better than 7 ft. Any discrepancy larger than 5' was thoroughly investigated. The discrepancy was normally due to an inability to precisely identify the same point in two strips. The use of the P.U.G. 1 to mark the points has eliminated this source of error.

Adjustment of the aerial triangulation is now carried out, using the analogue computer. Numerous premarked triangulation points enable a thorough check to be made on the accuracy of the adjustment. A graphical adjustment of the heights is found to be satisfactory, and this is used in preference to the analogue height adjustment.

Premarked points not co-ordinated in the field are fixed in the aerial triangulation process, and are plotted on the final maps as additional plane table control.

(v) *Plotting the detail and contours at 1:5,000 scale*

The grids are printed-down using a photomechanical process on to 0.010 astrafoil. A master grid was prepared on the Coradi co-ordinatograph, and from this master grid, an astrafoil reversal was prepared. This astrafoil reversal is now used to print-down grids (parallel to the sheet edges or skew) as and when required. Some 100 grids a month are prepared by this method. In addition to a considerable saving of the draughtsman's time, this process ensures that every grid used is as accurate as the original master.

Control supplied by the computing section is then plotted on each overlap, using the Coradi co-ordinatograph. By this means no machine time is lost by operators plotting their own control.

When the Survey of Kenya purchased its first plotting machines, in early 1957, a comprehensive training programme to produce machine operators was commenced. By early 1958 the departmental machines came into full production and since then, it has proved possible to meet all commitments departmentally. Until 1958, some mapping was contracted out to Air Survey firms.

The plotting is done on Nistri photo-mappers or Klesh plotters (all the operators on these machines and also on the Wild A.8's are locally trained). The overlap consisting on the average of some 2,000 acres, takes approximately 4 days to plot. Contours are plotted

up to 25′ V.I. depending on the steepness of the ground. It is occasionally necessary to plot an overlap on the A.8 because the height range of the other machines is insufficient to deal with the differences in height in a particular model.

(vi) *Photographic enlargement of detail to 1:2,500*

The machine plots are produced at 1:5,000 scale. The base map is required to be at 1:2,500 scale of a suitable size to fit on a 24″ plane table. A format was therefore chosen of 4,000 ft. square on the 1:2,500 scale. Such squares are marked on the 1:5,000 machine plot and twice enlarged using a process camera. The copy board of the camera has been modified so as to make this process largely mechanical.

(vii) *Fair drawing of base maps*

The resulting negatives are traced on a light table, on to 0.005 astrafoil. Normal 50″ × 25″ sheets of plain 0.005 astrafoil are cut in half, the resulting 25″ by 25″ sheets being ideal for the purpose.

No attempt is made to attain a high standard of draughtsmanship for these base maps, since the nature of their use makes their life extremely short. Once the land is consolidated the detail (except, of course, the contours) is completely changed. A green pencil (e.g. a Faber-Castell clutch) is used for the tracing, experiments having shown that the prints from this coloured lead are most satisfactory, having a longer life in the field. All these sheets are drawn on pre-determined and unique sheet lines, with sub-locational boundaries clearly shown. It is necessary to despatch, to the field, the sheet required to cover each sub-location. Sheets covering the edges of the sub-locations are therefore sent in duplicate.

The areas, on each sheet, included in a sub-location are shown, so that the Provincial Administration who deal with the land consolidation in the field can produce a correct total area for the sub-location. This is a most important feature in the process, since it is against this area that the total of the fragments must be compared.

In general, three prints of every sheet covering a sub-location are sent to the land consolidation teams.

Some 2,000,000 acres of mapping had been issued to the field by the end of 1962.

(viii) *Use of base maps in the field*

The base maps are used by plane tablers working for the Provincial Administration, to position on the map and then to lay out on the ground, the consolidated plots. The adjudication of rights and the positioning of the plots is largely carried out by a sub-locational committee of elders.

(ix) *Tracing of plot boundaries for interim registration index maps*

The prints which have been used for this purpose are returned to the Survey Department, and the plot boundaries and numbers are traced on to 0.005 astrafoil. Again, green pencil is used for the tracing.

Prints of these fair drawings are issued to the Registrars for use as index maps in the district registers. The master tracings are held in the Department.

Duplicates of the original registration sheets which make up the register are also sent to the Department by the Registrar for safe keeping. A cross check is then made by the Department between these registry sheets and the index maps. Numerous queries arise from this check (duplicate numbering etc.) which are settled before the issue of the final index maps.

C. PRODUCTION OF FINAL REGISTRATION INDEX MAPS

The final maps are produced from aerial photography, taken when the planted hedges or fences are visible from the air. For reasons of economy and planning, it is necessary to photograph and map reasonably large areas. Within these areas the hedges have been in position for times varying from three months to two years. Although it was considered that a growth of over one year would be desirable, the incentive of the refly causes the consolidation teams to plant many missing boundaries just before the time of the photography takes place. Many hedges are therefore too small to be seen easily on the air photographs.

In order to facilitate the plotting of these boundaries, the Provincial Administration are asked to clear away the vegetation on either side of the hedges to a distance of 1½ feet, this amount of clearing having proved to be the most suitable after experiments had been carried out. The Administration were very successful in carrying out this tremendous task—in Kiambu District alone, some 40,000 plots were involved. That over 90 per cent of the boundaries are plotted on the machines is proof of the thoroughness with which the clearing was carried out. On investigation, however, many of these cleared lines no longer are hedged. It is apparent that most of the boundaries missed were *never* planted. A requisite therefore, of the subsequent ground survey of these missing boundaries is the planting of the hedges demarcating the boundaries.

(i) *Premarking of the triangulation control*

For the "refly" all control points are premarked with crosses, having legs 10 ft. long and 1 ft. wide, the premarking commencing 1 ft. from the point.

(ii) *Aerial photography*

Since the registration of the plots was based on hedges which approximate to 2 ft. in width, it was decided that the final maps should be produced at a scale of 1:2,500, on which the plottable accuracy is of the order of 3 ft. It was decided to plot directly at 1:2,500, from photography of 1:12,500 contact scale, in order that no accuracy should be lost through photographic enlargement. The larger contact scale also rendered more easily visible, any hedges which were still very small.

(iii) *Additional ground control*

It was anticipated that the control obtained from the aerial triangulation adjustment of the original 1:25,000 photography would be adequate to obtain the further

control necessary for plotting the 1:12,500 photography. The ground detail changes subsequent to Land Consolidation were, however, so far-reaching that this method did not prove possible. It was therefore necessary to completely control, by ground survey, the 1:12,500 photography. The minimum requirements of the Zarzycki method of adjustment determined the number of additional points asked for.

The majority of this additional ground control has been fixed by Tellurometer traverses, a method which is ideal for the fixing of photo control. The use of the analogue adjustment has virtually eliminated the additional points which it was previously necessary to fix by ground survey.

(iv) *Aerial triangulation and adjustment*

The diapositives are prepared on the logetronic printer and the aerial triangulation is done on the Wild A.7. The analogue computer is used for adjusting the strips.

(v) *Plotting boundaries at 1:2,500 scale*

The three Wild A.8 stereoplotting machines are used for this work. Efforts were made to obtain satisfactory results from the Kelsh plotters or the Nistri photomappers. Extensive experiments were carried out, on all three types of plotting machines. A test area was accurately ground-surveyed and the same area plotted on all three types of machines. Care was taken to use the operator most skilled on each particular type of machine, and all operators were informed of the experimental nature of the work. The accuracy of the plotting was in this order:

(i) Wild A.8;
(ii) Nistri Photomapper;
(iii) Kelsh Plotter.

The anaglyph machines had difficulty in accurately plotting through shadows of high detail. It was also found that very small hedges, whilst visible on the A.8, were not visible on the other two machines. Overlaps were plotted on the A.8 and on the Nistri photomapper (the illumination is better on the Nistri photomapper than on the Kelsh plotter), and many more boundaries were missed on the Nistri than the A.8. To ground-survey these missing boundaries involve much time and money in extra field work. On taking these points into consideration, it was decided that the final cadastral mapping would all be done on the Wild A.8 machines.

An average machine-plot consisting of approximately 500 acres, containing on the average some 70 plots, is plotted in one and a half days, which time includes the absolute orientation of the model.

As for the base mapping, the grids on the 0.010 astrafoil are photomechanically reproduced and the control is plotted in the preparation section, using the Coradi co-ordinatograph.

(vi) *Ground survey of any plot boundaries missing on machine plot*

A "query" section examines the machine plots and compares the boundaries against those appearing on the interim registration index maps. It is thus possible to show a missing boundary by means of a pecked line and any doubtful boundary as a query. Prints of the overlaps are then sent to the field staff who ground-survey the missing boundaries and investigate the queries.

(vii) *Tracing of final registration index maps and computation of final areas*

When the prints have been returned from the field, the ground-surveyed boundaries are plotted on the machine-plots from the measurements supplied by the field staff.

From the machine-plots the master tracings of the final registration index maps are made. Again for convenience of storing and handling, 4,000 ft. squares are chosen. All the information appearing on these master tracings (e.g. title, grid, etc.) with the exception of the plot boundaries and the plot numbers is photomechanically reproduced on the 0.005″ astrafoil sheets. The draughtsman's task is therefore reduced to the minimum.

Since the shapes and sizes of the plots as depicted on the original index maps are changed due to more accurate survey, it is necessary to compute new areas. The plot owner accepted a piece of ground in exchange for his fragments and not a specified area, so at this stage the exact area of his plot for registration purposes, is computed.

The computation is done twice, once from the machine plot and once from the master tracing. A check is therefore made on both the accuracy of the computation and the accuracy of the compilation.

Prints of the tracings are sent to the district to replace the interim registration index maps, together with lists of the final areas.

By the end of 1962 some 240,000 acres of final mapping comprising 50,000 plots had been handed over to the Registrar.

4. Variations in the procedure

The procedure as outlined above, is standard for all districts in Central Province. There are, however, variations in this procedure in other areas.

(*a*) In *Nyanza Province*, the principle of complete consolidation has not been accepted by the African landowners. They have, however, agreed in some areas that hedging roads of access and straightening out of boundaries is desirable. The object in view therefore, is again that the plots to be finally registered, will conform to the best agricultural pattern it is possible to achieve in the circumstances.

The first part of the standard procedure is therefore not applicable and is replaced by the following:

(i) The plot owners are encouraged to carry out hedging etc. by themselves.

(ii) When a block of some 50 sq. miles has been treated in this manner, the area is flown at 1:12,500 contact scale.

(iii) The prints are issued to the field and suitable well-defined registration units are chosen. The plots are annotated on the photography by chinagraph pencil either from visible hedges or by local agreement referred to detail visible on the prints. An index to the plots

is traced and information on plot owner and state of hedging annotated.

(iv) The index is then handed to the Provincial Administration who, in co-operation with the Agricultural Department, advise the plot owners on the desired improvements. Some considerable time elapses before the final hedging is complete.

(v) When the hedging is complete—after say a two-year period—the areas are re-photographed at 1:12,500 scale, and the final registration maps prepared according to "C" of the standard procedure.

(*b*) *Rift Valley Province* also sees a departure from the standard procedure. As in Nyanza Province, the register records existing rights. The details of the procedure which differ from the Nyanza Province, are as follows:

(i) Base maps are supplied to the Agricultural Department which puts on the ground the major soil conservation works.

(ii) The plot owners are then informed of the intention to register their plots and are encouraged to enclose. The presence of the soil conservation works assists in obtaining a more sensible pattern of enclosure. When the enclosure pattern has been completed to his satisfaction, the registering officer uses the base maps to plane table the plot boundaries.

(iii) The remaining processes conform to the standard procedure given in detail above.

5. Experiments

Since the problem of the consolidation and registration of African small holdings first arose in Kenya, the procedure as outlined has been largely formulated as a result of our own experiments and experience.

The following experiments have helped considerably in determining the details of the procedure:

(i) Various methods of using the Tellurometer for fixation of additional control were tried. Undoubtedly, the traverse and the ray-trace have proved the most satisfactory.

(ii) Various types of premarking were photographed at the two scales utilised, and the methods of premarking as listed in the standard procedure were adopted.

More recently, experiments in premarking to previously determined flight lines have been conducted. These have been so successful that in future it is anticipated that blocks of photography will be compeletely controlled by premarked points and the necessity to fix photo identified points will not arise.

For plot corners in areas where hedging is not possible, a circle of 3′ diameter was found to be satisfactory for 1:12,500 contact scale photography if the marks could be identified by cleared lines. In areas where line clearing cannot be carried out, it is better to premark the corners in the form of a 5′ diameter *ring*, the ring being 1′ across. The 3′ diameter circle is liable to be confused with small blemishes on the photographs.

(iii) A strip of photography was taken across an area which included hedging at all stages of development. It was decided that the hedging should be in position for a minimum of one year before the final photography is taken. It was not visualised that in fact some boundaries would not be planted at all.

(iv) In connexion with the experiment in (iii), a strip was taken using first, infra-red, and then panchromatic film. The result seemed to show that simult aneous photography would be desirable. However, the results from the first block of photography, for mapping property boundaries, using panchromatic film only, were so good as not to justify the extra expense of asking for the additional infra-red photography.

(v) As mentioned previously, an experiment was done to control the 1:12,500 photography using the 1:2,500 aerial triangulation control obtained two years previously. The experiment failed due to fundamental change in local detail.

(vi) The experiment using the different plotting machines has already been outlined.

Conclusions

As has been explained, every effort has been made to streamline the photogrammetric processes, and photomechanical means have been used wherever possible. It was always realized that too great a stress on refinements and accuracy would endanger the success of the whole project by slowing down the production of the maps.

The decision was reached at an early stage that no effort should be spared to train local personnel to operate the plotting machines. That the decision was fully justified is now proved in that locally-trained personnel operate competently, all plotting machines, with the exception of the Wild A.7.

The analogue computer is of the utmost assistance, and the premarked points will provide ample control in the future, doing away with the necessity of asking for additional field control. This will eliminate the few discrepancies which have occurred in fixing additional points. The errors have been mostly due to choosing points difficult to identify rather than errors in field survey. Experience has proved that use of the analogue height adjustment is not worth while.

Errors have occurred through the inability of the preparation section to transfer the points precisely between overlaps and especially between strips. The acquisition of the Wild PUG 1 point transfer device has largely eliminated the possibility of any further errors of this nature.

It is necessary to keep all of the processes enumerated under constant review and to make changes where such changes lead to more efficient production. For example, the photomechanical printing-down of grids has been replaced by the printing-down of grids by lithography now that a flatbed proving press is available.

ASSISTANCE GIVEN BY THE FRENCH CADASTRAL SURVEY DEPARTMENT TO AFRICAN STATES[1]

Cadastral Survey Department, Ministry of Finance, Paris

For a number of years past, the Cadastral Survey Department has been assisting various African States under the heading of technical co-operation in different forms:

Organization of special training courses for the benefit of nationals of the territories concerned;

Despatch of qualified experts whose services may be made available to Governments for periods varying from a few months to several years;

Assignment of officials, under the terms of Technical Assistance, to topographical services in Algeria, Morocco and Tunisia;

Supply of documents.

This list requires further details:

Training courses

Several series of training courses have been organized, during the years 1951 to 1963, with the aim either of completing the professional training of officials from various African States, or of providing as complete a basic training as possible for holders of scholarships sent by their Governments, and destined to enter the public services of their countries.

The advanced training courses have been devised with a view to permitting those concerned to acquire, within a limited space of time, sufficient knowledge of the work and organization of the Cadastral Survey Department; in general, these courses are conducted on the following lines:

About five months of study at the Ecole du cadastre (School of Cadastral Survey) at Toulouse, where the trainees follow an accelerated training course dealing with the subjects contained in the syllabus for student inspectors and trainee technicians of the Cadastral Survey Department: records of the work of the French Cadastral Survey Department, organization and functions of the Cadastral Survey Department, land taxes.

Those concerned are besides initiated into the works of renovation and conservancy of the Cadastral Survey (office work and work in the field);

A visit, for purposes of information, lasting about 10 days to the Service de la documentation nationale du cadastre (National Documentation Service of the Cadastral Survey) with lectures, visits to the workshops engaged in the reproduction of plans, practical demonstrations, particularly in photogrammetry;

Assignment to the Cadastral Service of one of the departments of the Lower Rhine, Upper Rhine or Moselle, in the course of which the trainee will study the peculiarities characterizing the cadastre of Alsace and Lorraine that due, in particular, to the existence of the Land Register.

The training courses for young scholarship-holders have been the same as those organized for the benefit of student inspectors of the Cadastral Survey, and they last two years.

The students from African countries, who have been accepted up to date for these training courses, may be divided as follows:

Six land-surveyors from the Topographical Service of Cameroun, in 1951 and 1953;

Two officials from Sudan, one from Cameroun and 2 from Dahomey, in 1959 and 1960;

Three land-surveyors from the Ivory Coast and 1 from Dahomey, from 1961 to 1963;

One official from the Congo and 2 from Upper Volta, in 1962 and 1963.

In addition, the Cadastral Survey Department has received and documented the following:

Two senior land-surveyors of the Topographical Service of Morocco who from 6 November to 12 December, 1959, followed the work carried out at the Brigade topographique nationale (National Topographical Detachment) in Paris, in particular on the subject of aerotriangulations by means of radial slotted templets and the operation of the Usine de reproductions et tirages (printing plant) at Saint-Germain-en-Laye; these engineers have, besides, studied the operation of the Cadastral Office at Meaux, on the spot;

Two land-surveyors from Dahomey, who were received in October 1962 at the Brigade topographique nationale to study, in particular, photogrammetric processes there.

Despatch of experts

The Cadastral Survey Department has been frequently notified of requests coming from French-speaking African States for the assistance of experts from the Cadastral Survey for shorter or longer periods.

A mission of this nature is generally placed under the auspices either of the French Minister of Co-operation or of the United Nations.

The Cadastral Survey Department has a small staff and cannot easily dispense with the services of experienced officials, yet it makes every effort to meet requests for assistance.

The following requests have been received recently:

From the *Republic of Mali*, where a central inspector of the Cadastral Survey has just completed a mission of 3 months, the aim of which was to determine the present situation and to suggest, if that appeared desirable, the broad outlines of reforms, in particular by establishing a Cadastral Survey Department, if that proved necessary;

From the *Republic of the Ivory Coast*, which wishes to work out the projects of land reorganization, the prin-

[1] The original text of this paper, submitted by France, under the title "Interventions du Service du Cadastre français auprès des États africains," appeared in French as document E/CN.14/CART/15.

ciples of which it has laid down. An expert is on the point of being sent to Abidjan;

From the *Congo Republic* which requires the dispatch of a French expert of the Cadastral Survey to spend a year with the Service topographique et du cadastre (Topographical and Cadastral Service) at Brazzaville, in order to:

Assist the Director of the said Service in working out the system of the "Cadastre coutumier rural" ("customary rural cadastre") owing to the enforcement of the new Congolese State land regulations (survey of the customary land rights, both individual and collective);

Prepare service instructions (both detailed and practical) concerning the procedure for drawing up the various cadastral documents, their registration and preservation in the archives);

Begin putting the procedures adopted into practice;

Train qualified operators for the functioning of a conservancy department;

From the *Republic of Chad* which, under the heading of Technical Assistance, would like to utilize the services of two senior land-surveyors to strengthen the present establishment of the Chad Cadastral Survey Department, and hopes that candidates for these posts can be recruited from among the officials of the French Cadastral Survey Department.

When the Governments of the Congo and of Chad have supplied additional information on the service conditions of the two officials of the Cadastral Survey, who would be placed at their disposal, there is every reason to think that their request will receive a favourable reply.

Officials at present assigned under technical assistance

At present, a considerable number of officials have been assigned for duties with the Algerian, Moroccan and Tunisian States under Technical Assistance.

Those concerned are generally former officials of the local topographical services, who having been reintegrated into the French Cadastral Survey Department, agreed to continue to serve in their original administrative services after those countries acceded to independence.

Those performing such duties are as follows:

In *Algeria:* 6 officials of category A, 5 of category B, 8 of category C, and 6 of category D;

In *Morocco:* 19 officials of category A, 10 of category B, and 2 of category C;

In *Tunisia:* 3 officials of category A, 6 of category B, and 1 of category C.

Project in process of execution for Algeria

In order to meet requirements for the training of topographical engineers, the French Ministry of Finance, in agreement with the Algerian authorities, has recently consented to place several inspectors of the Cadastral Survey at the disposal of an *école de topographie* (school of topography) established at Oran, which is at present providing limited instruction thanks to "the French staff remaining in Algeria".

The collaboration of these instructors, which is expected to continue for 6 months, would enable the School to commence theoretical instruction with courses in topography, drawing and procedure, complemented by experimental work in the field.

The execution of this measure is being reviewed jointly with another project which would consist in instituting a special training course at the Ecole nationale du cadastre (National School of Cadastral Survey) for the benefit of some fifteen young Algerians, who would be holders of the *elementary certificate of matriculation in mathematics*, and candidates for the post of topographer with a degree in unit engineering.

Hydrographic surveying

HYDROGRAPHY ANT ITS IMPORTANCE TO MARITIME SAFETY AND ECONOMIC DEVELOPMENT[1]

By William S. Davies, U.S. Naval Oceanographic Office

A large share of the world's commerce is carried between ports and countries in ships. These ships and their cargoes represent an enormous investment in money and carry crews and passengers as well. Therefore it is essential that all the information necessary for the safe navigation of these ships between ports and across the oceans be available to the ship masters. Such information consists of nautical charts of various scales covering ports, coastal areas and the oceans, and books such as sailing directions (coast pilots), light lists and tide and current tables. New information on dangers and aids to navigation is developed continuously through the conduct of survey operations, the placement of buoys, and the destruction or erection of navigational aids such as light houses and conspicuous land marks. Consequently, the nautical charts and books of the navigators must be constantly corrected to include the latest information which is made available to them by radio broadcasts (for urgent information) and by printed notice to mariners (for important but less urgent information). All of these activities:

[1] The original text of this paper, contributed by the United States of America, appeared as document E/CN.14/CART/60.

1. The conduct of surveys in ports, along the coasts and at sea,

2. The publication of nautical charts and books and

3. The improvement of the existing charts and books through the dissemination of information by radio and printed notice to mariners

are the normal functions of a nation's hydrographic office.

Not all maritime nations have a hydrographic office at the present time. It is believed that eventually each will establish such a service to assist in its economic development by providing ship masters with the latest information and thus make voyages between ports safer. Some comments concerning the establishment of a new hydrographic office follow:

A new hydrographic office should concern itself first with establishing a system by which all information pertaining to maritime safety is rapidly collected and evaluated at a central point and published for the benefit of mariners as quickly as possible. Such information includes data on lights, beacons, buoys, recommended channels, least depths on shoals and in channels, wrecks, derelicts, and other items essential to safe navigation. It is particularly important that a complete list of navigation lights and buoys be published as soon as possible. All possible use should be made of existing organizations and personnel (such as pilots, customs agents, light and buoy attendants, and ship masters) for collecting and reporting all information to the hydrographic office. The hydrographic office should then consolidate the information and issue notice to mariners to ship masters and other hydrographic offices. This can be done inexpensively using mimeographing or other office type reproduction methods. If radio facilities exist, urgent information should be broadcast for the benefit of ships approaching the coasts. Personnel employed to carry out this maritime safety function should have had considerable experience in navigating ocean-going ships.

Secondly, a new hydrographic office should endeavour to improve existing nautical charts of its principal ports and their approaches by conducting complete hydrographic surveys which include depth determination, location of all aids and dangers to navigation, delineation of shoreline and harbour features, and tide, current and bottom characteristic observations. Here again, existing facilities and personnel should be utilized to the maximum extent. The vessels employed in pilot service and in tending buoys, lights, and beacons could be used as survey vessels by equipping them with suitable depth recorders and survey positioning equipment. High quality harbour surveys can be made by a six man crew using a boat as small as 26 feet equipped with a suitable depth recorder, two sextants, a protractor and a clock. Before such operations can begin however, sufficient daymarks on shore must be located on the survey sheets by standard survey methods involving baseline measurements, triangulation, and azimuth determination. A tide staff or automatic tide gage must be in operation during the period of the hydrographic survey so that all depths can be corrected to the same datum. A permanent tide gage at each principal port would be highly desirable. Personnel employed to conduct hydrographic surveys should be experienced in this type of survey. Civil engineers or land surveyors with some training or experience in hydrography generally make good hydrographic surveyors.

Upon completion of field survey operations in an area, the data must be carefully plotted and verified on the manuscript sheets before charts can be published. Publication of standard nautical charts of principal ports is the third most important function of a new hydrographic office. The preparation of a nautical chart original plate suitable for printing requires the services of a cartographer experienced in nautical chart work. Cartographers, civil engineers, hydrographic engineers, and in some cases, draftsmen familiar with the the preparation of topographic maps or nautical charts provide a source of personnel for the production of a nautical chart. It is not necessary, however, that a printing plant be organized at the hydrographic office if arrangements can be made to have the work done by other government or commercial printing facilities.

After a hydrographic office has a firmly established navigational warning system and has completed hydrographic surveys and charts of its principal ports, it will naturally expand its survey and charting activities to include all its coasts. This fourth function may require larger boats and additional personnel, but very large survey ships are not required if temporary bases for smaller ships can be established at various inhabited areas along the coast.

During harbour and coastal survey operations, the survey personnel should collect all the navigational information available so that eventually, a book of Sailing Directions may be compiled and published by the hydrographic office. Compilation of the sailing directions by a fully qualified navigator constitutes the fifth function of a hydrographic office and completes the list of services normally performed for the benefit of navigators. Additional services, such as oceanographic surveys for the benefit of the fishing industry or science generally may well be added.

In conclusion, the following points are emphasized:

1. The economic development of a maritime nation depends greatly on the sea transportation of materials and people.

2. Safe and economical sea transportation depends upon a high degree of maritime safety.

3. Maritime safety can only be maintained through the prompt dissemination of hydrographic information and

4. Prompt dissemination of hydrographic information can be accomplished when each maritime nation has established a hydrographic office.

COASTAL GEOGRAPHIC AND NAUTICAL CHARTING[1]

By H. Arnold Karo, B.S., Sc.D. Rear Admiral, USC &GS, Director, U.S. Coast and Geodetic Survey

General

The Coast and Geodetic Survey of the U.S. Department of Commerce performs public services essential to the safety and advancement of marine and air commerce, to surveying and mapping and other engineering work, and to the economic development of natural resources. The early leaders of the nation wisely considered such services as elements of the constitutional responsibility of the nation to promote and develop trade and commerce between the several States and with foreign nations. Ferdinand Rudolph Hassler, the first Director of the Coast Survey, made the following statement before a committee of Congress in 1841:

> "The aim of the Coast Survey is, and has always been considered to be, by all the successive administrations since its existence, to furnish, with the fullest accuracy possible, all the geographical, topographical, and hydrographical data that may in any way be needed for the navigation and defense of the coast in their generality, and to the extent of the country in the rear of the coast, to which the valleys extend... and that this work should also furnish the elements to any future map of the country desired, as it is by its nature so extensive, and so situated, as to furnish the elements of maps of all the states."

As a maritime nation with its thousands of miles of coastline, the United States must have a continually expanding knowledge of the sea around it, its coasts, the location of dangerous reefs and shoals, the extent of fishing banks and submerged lands, the rise and fall of the tide, the direction and strength of sea currents, and the magnetic disturbances affecting its navigation and communications. Air commerce activities of the United States require a continually expanding knowledge of vast terrain, the natural and man-made hazards to air navigation reaching into the air space, and all of those details which find expression on a modern aeronautical chart. The promotion of the commerce and industry of the United States requires a continually increasing knowledge of natural resources, of the details of the topography and geology of the national domain, and of the potentials for developmental measures to further trade, commerce, and living conditions generally.

Directly or indirectly the work of the U.S. Coast and Geodetic Survey affects the daily lives of all Americans and many citizens of other countries. The ships that bring coffee from Brazil and sugar from the Philippines as well as the recreational boater in pursuit of adventure and for relaxation use the nautical charts of the bureau. The air pilot who carries passengers, mail, or cargo uses its aeronautical charts to guide him safely to his destination. The surveyor who locates the boundaries of farms and city lots and the engineer who plans hydroelectric, superhighway, flood control, and other construction projects use the networks of geodetic control markers which the Survey has established throughout the land. The safety engineer who establishes building codes against earthquake hazards uses the information furnished by the Survey to determine the stresses and strains that buildings must withstand.

Coastal surveys and investigations

The U.S. Coast and Geodetic Survey has had a long and continued interest in coastal conditions, which is a natural outgrowth of bureau responsibilities in the fields of hydrography, oceanography, and topographic surveying. During the 156 years since the bureau was created, many changes have taken place in surveying methods and techniques. Each change has resulted in accumulation of more accurate and more detailed information.

Accurately executed surveys of coastal areas have been in progress since 1832. Over the years since that time, more than 18,000 individual surveys have been completed and are on file in the bureau archives. These original surveys represent a unique and comprehensive record of the U.S. coastline and adjacent waters. They show conditions existing at particular dates over more than a century, and provide a timely record of the changes that have occurred from natural and man-made causes.

Photographic work has been an important supplement to coastal surveying activities for many decades. Photographic records of the bureau contribute substantially to the comprehensive record of coastal conditions and changes. The scope of our records has broadened as bureau operations have been progressively enlarged in keeping with national growth and expansion.

Coastal geographic studies take into consideration nature's complex processes in forming a coastline. Important factors to be considered and understood are the configuration of a locality and the activity of the elements. Incessant attack by the sea upon points of land projecting into the water erodes away materials which are transported to other places and deposited as accretions to existing forms or as contributions to the formation of shoals and bars. Natural forces working in varying degrees of effectiveness upon inlets create a constantly shifting arrangement of channels or the migration, opening, or closing of an inlet, and a readjustment of shore forms.

Progress in the evolution of shoreline configuration is usually gradual but, occasionally, changes occur so rapidly and in such a strategic location that a definite marine hazard results which requires immediate action. This was the case in the great Atlantic storm of March 1962 with its massive assault on the East Coast of the United States. The U.S. Coast and Geodetic Survey immediately undertook the difficult task of photographing and surveying the coastal changes and issuing emer-

[1] The original text of this paper, contributed by the United States of America, appeared as document E/CN.14/CART/64.

gency chartlets to insure safety in navigation until the regular editions could be changed. Revised charts are now being issued based on new surveys and air photographs.

The long coastline of the United States totalling over 100,000 miles of tidal shoreline presents many and varying problems in coastal geography. Added to this vast area to be charted are extensive intracoastal waterways and many bays and harbours. Thus 80 per cent of the nautical charts published by the Survey are at relatively large scales (1:40,000 or larger) for navigation in the more or less restricted intracoastal waters. In these waters the navigator is often close to land and is vitally concerned with the shallow waters along the shore and features of the shoreline and the nearby land. To meet these contingencies the bureau began over 30 years ago to use aerial photography and photogrammetric techniques to make the surveys required to position and portray the land information on nautical charts and, most important of all, to keep this information up-todate.

Over the last quarter-century much attention has been given to the development of aerial photography and photogrammetric techniques to meet nautical charting requirements. In developing an effective photogrammetric organization, use is made of panchromatic, infrared, and colour aerial photography for both interpretative and location purposes; analytic aerotriangulation procedures have been introduced; and refined methods of photogrammetric measurement have been developed for effective application of photogrammetry to new problems. The value has been demonstrated in the United States of colour and infrared aerial photography for interpretative and geographic purposes; the procedures now in use should be most helpful to the African nations in the mapping and charting of the water courses, or rivers, and for the study of the environment of the lands bordering those water courses.

Among the advantages of colour photography for coastal geography is the fact that some 20,000 separable colours can be recorded by this relatively new medium. Certainly the geographer can appreciate the advantage of this fact in photo-interpretation. Moreover, colour photography is not particularly difficult to take and to process. Colour photography penetrates the water and photographs the bottom to some extent, depending upon the clarity of the water. The Coast and Geodetic Survey is now obtaining a clear picture of the bottom in depths ranging from 60 feet to 5 or 6 feet. Not only are excellent photographs obtained of the land and the foreshore but a picture of the underwater features along the shore as well. Moreover, colour photography is unsurpassed for the delineation of shoreline, alongshore rocks, and all details of the foreshore of interest to the mariner.

Infrared photography is used for exact mapping of a shore contour such as the mean-low water line or the mean-high water line. The light rays, or energy, of the infrared portion of the spectrum are absorbed by water. Little or none is reflected back to the camera lens; thus infrared photography shows a dark or black water area against the shore and clearly defines the contact line between land and water. The use of infrared and colour photography has resulted in new procedures in chart making.

Coastal mapping in connexion with nautical charting has accumulated an extensive and unique library of information about coastal geography that is most necessary for scientific study of coastal geography and engineering development.

C & GS objectives in coastal charting

The U.S. Coast and Geodetic Survey has the specific problem of publishing and maintaining over 800 nautical charts for the safety of navigation in the coastal waters of the United States and possessions. Added to this problem is the general task of maintaining records and supplying information about the coastal geography of the country which is required for the protection of the coastline and for economic development in coastal regions. Safety of life and property frequently depends directly upon the reliability of the Survey's charts and publications; and the geodetic control of the country is the foundation of all topographic and geologic mapping, land surveys, and many extensive engineering projects. It is therefore the policy to stress accuracy and dependability in all field observations and publications for which the Bureau is responsible.

Although the pioneering founders of the Coast Survey, with remarkable foresight, early in the 19th century established precision standards which have stood well the test of time, an increasing number of demands are being felt for greatly increased precision, particularly in geodetic measurements. The Survey has always followed the policy of obtaining the greatest degree of accuracy practicable, not only for the immediate needs but for the foreseeable future, and of making continual investigations and trials of new, more precise, and more efficient instruments and methods.

Coastline charting

The charted coastline is the most prominent feature on almost every nautical chart. It is usually bordered by an area of shoaling waters where the greatest dangers to the mariner are to be found. It is also an area where frequent changes, both natural and man-made, take place. In addition, the mariner utilizes charted features of the coastline for checking his position and making good a safe course to his destination.

The nautical chart differs considerably from the topographic map in its treatment of the coastline. The topographic map emphasizes the land forms and the representation of relief, with shoreline as an approximate delineation of the water line at mean sea level. In contrast, the nautical chart has such a unique requirement for detailed and accurate representation of the coastline that it must be considered in a separate category from the topographic maps in any discussion of coastal geography.

Geological distinctions are of minor import to the mariner; consequently, chart symbols are designed for easy interpretation by the navigator to convey quickly, clearly and unmistakably, the information necessary for

safe navigation. The graphic mediums for charting coastline features are usually employed in various combinations of individual symbols and symbol patterns; line drawings in which the line itself may be varied by symbolizing (weight, dashes, etc.); tints or screen tints; and legends. A complexity of symbols reduces the legibility of charts, thus simplicity for rapid reading and ease of interpretation is critically important in good chart compilation.

The mean high water line is the most prominent line on the chart. It is accurately surveyed by a special project and represented on the chart by a solid black line. If its delineation is only approximated, it is shown by a dashed line symbolizing that fact. (Such a situation occurs where formerly surveyed shoreline has undergone changes and until the area can be resurveyed an approximation from the best available information is charted.) The mean high water line is further emphasized by a "fast-land" tint on the land side and a contrasting shoal water tint on the water side. Its configurations are important to the mariner when close to shore as it depicts the usual appearance of the shoreline.

The accurately determined mean high water line will also reveal the physical geography of the shore. It reflects the effects of prevailing currents, wave fronts and storms by characteristic outlines such as marshes or swamps that frequently occupy low-lying areas that are covered at high tide. Marsh is a feature that can visibly be identified by a mariner, and swamp is a feature that must be avoided in making a landing.

The mean high water shoreline delineates the seaward limits of both marsh and swamp features, for to the mariner this limit appears as the visible shoreline. The extent to which these features penetrate the back shore area is represented by a fine dashed line. Marsh areas carry a green tint and, where space permits, the legend "marsh" is added. The green area stands out clearly against the fast-land tint and depicts the characteristic break in the topographic background which marsh grass presents to an observer. The seaward extent of marsh is accurately surveyed, but the inshore boundary may be generalized as the ragged indentations into the fast land are of little importance on the nautical chart. Swamp is represented by the fast-land tint but with a legend "swamp" or "mangrove". The vegetation of swamp land makes it appear as fast land to the mariner, hence knowledge only of its general location is sufficient for charting.

Seawalls, bulkheads and other man-made structures on the shoreline are represented on the chart by their outlines. The mean high water line around such structures projecting into the water is reduced to a width of 0.006 inch. The fast-land tint is overprinted on these features. They are not generally labeled as they can usually be identified by their shapes or by their proximity to other cultural features. Structures which also form a part of the shoreline and which extend underwater, such as marine railways or ramps, are represented by dashed line showing that portion which is covered at high water.

The outer limit of the foreshore area which is that part of the beach between high and low waters at ordinary tides is generally determined by hydrographic surveys. On a gently sloping coast the area which uncovers at low water may reach a considerable distance from the mean high water line. This low water line is represented on the chart by a dotted line if it is other than ledge rock. This area is emphasized by a green tint between the mean high water and the low water lines. Within this foreshore area the effects of the sea cutting into the shore, such as scoured ledge rock or scattered boulders need to be charted. A ledge symbol pattern shows ledge rock which uncovers, and individual "rock awash" symbols show scattered rocks which uncover at some stage of tide. Where a ledge extends below the low water level the use of sunken rock symbols or an area labeled "foul" and outlined by a dashed line will represent the feature for chart purposes.

Coral or lava rock are treated the same as rock ledge since they are the same in their hazard to the mariner. They are seldom labeled since identification can be inferred from the locality.

Legends are used for describing conditions which cannot readily be represented by symbols. Legends such as "boulders", "wreckage" or "foul area", with dashed limits if needed, may be charted over an extensive area.

Backshore is the term applied to that part of the coast which extends inland from the mean high water line to the marine cliff or bluff marking the limit of storm waters. The marine cliff or bluff is charted if it has landmark value or if it presents an obstacle to landing. The symbol used for rock outcrop or cliff differs from that used to show a steep earth bluff. Both symbols are designed for easy reproduction. They do not directly indicate height, but may be drawn to suggest relative heights. In the latter case they may exaggerate the features on some charts; however, their purpose on a nautical chart is to show clearly the location of a feature for its landmark use. Contours, if shown on the chart, are ended at the bluff or cliff symbol.

Where the shore is lined by ledge rock exposed by the sea a bluff symbol along the mean high water line is omitted. The charted ledge rock indicates the cutting into the land that is taking place and a bluff at the shoreline would be expected. There the bluff is incidental and its symbol is omitted to permit emphasis on the off-lying ledge, which is the critical information for the mariner.

Reflected light from a strip of sand or sand dunes along the shore may help to identify a locality or advertise a possible landing site. A symbol is thus used to represent sand beach on the chart. The symbol can be modified to show gravel or rocky beaches, and a general symbol to indicate an area of sand dunes, since the dunes are continually changing. On a smaller scale chart the legend "dunes" replaces the symbol.

A blue tint is charted for a selected offshore area adjacent to the foreshore. The outer limit of this area is a chosen depth curve, the selection of which varies according to the area and type of chart. This tinted area emphasizes to the mariner the approximate extent of the marine beach. It is not a definition of the width

of the beach, but it will generally include that portion which is most affected by deposition and erosion. It is the area where bars, reefs and isolated rocks are usually located. The information for charting this area comes from hydrographic surveys and field examinations. Surveys are more intensive in such areas, hence the depth curves are defined in greater detail and reveal more of the nature of the bottom configuration. Depending on the scale, the nautical chart will reflect all of this detailed information to the blue-tint zone.

Modern photogrammetry in charting

Earth mapping is in reality a composite of the mapping which each country in its sovereign capacity undertakes in the interest of knowledge generally, and as an essential to the promotion of its economic welfare. Methods and equipment may differ somewhat, but the essentials are the same. Electronic methods, in one form or another are used by nearly all maritime nations for surveying the waters bordering their seacoasts, and aerial photogrammetric methods have become the universal medium for surveying the land features.

Natural causes such as wind, tide, current, and storm erosion are forces that affect chart maintenances activity. Shoreline changes by commercial development of waterfront facilities and the expanded highway programmes with resultant changes in bridge clearances and topographic culture are a few of the man-made conditions that add to the chart maintenance burden. Aerial photographs from panchromatic film is the basic medium from which the shoreline has been compiled but colour is the new photogrammetric concept being developed for recording these phenomena.

The many aids to navigation, including buoys, fixed beacons and lights in our harbours and along the intracoastal waterways show clearly on colour photography and can be readily located by photogrammetric measurement. By use of infrared photography, the water surface is reflected with little or no depth penetration. The water line contour is well defined, and when taken in conjunction with the high and low stages of the tide, the high water and low water lines can be extracted for chart construction. Other colour film mediums have a water depth penetration quality that can be interpreted with certainty in relatively clear waters.

This new concept in photogrammetry is applied primarily for nautical charting. Shoreline maps are prepared for inshore hydrographic surveys and include such coastal geography as foreshore detail, underwater channel lines, shoals, and rocks, etc. These features guide and supplement the hydrographic survey in the detail work in shallow waters adjacent to the shore.

The physical geography depicted on nautical charts is revised by use of new aerial photography as an integral part of the chart maintenance programme. The shoreline is compiled at chart scale for direct application to the chart drawings, and the location of the aids to navigation and special landmarks are an integral part of the information furnished by the photogrammetric processes. Colour photography is especially useful for this process.

Electronics in charting

The magic word in modern mapping and charting is electronics. The whole field of surveying and mapping on land, sea, and in the air has undergone, or promises to undergo, a face-lifting. The surveyor has discovered that he has a new yardstick at his disposal; namely, the velocity of propagation of radio and light waves. An instrument using that yardstick can be designed to reduce the cost of surveys and even to accomplish surveys heretofore impossible with conventional methods. The maintenance cycle of nautical charts has likewise been increased by the volume of new data made available through the advanced developments of electronic surveying. These methods have steadily improved, resulting in more accurate hydrographic surveys and photogrammetric information. The rapidity with which depths can be measured and topographic information collected has increased the total amount of data available for application to the nautical charts.

Automation in surveying and charting

Due to the unprecedented demands in this modern era for cartographic products and the wealth of source materials now available for their construction and revision, chart production must be accelerated with a corresponding reduction in the time span between inception and publication of a map or chart. Many of the cartographic operations which are now performed manually will be accomplished by automation; some automatic processing already has been developed. For example, an automated system for processing hydrographic data for nautical charts has been developed and is now in test and evaluation.

Involved in this project is the use of new equipment aboard one of the ships of the surveying fleet which acquires, records and stores survey data in a form acceptable to a shorebased computer. These data are recorded as a typewritten record and as a punched paper tape. The tape is suitable for forwarding to a computer-plotter complex where smooth copies of the survey will be plotted automatically. These data are used to guide an automatic plotter in ruling a grid, in plotting the positions of charted features, and in plotting the corrected soundings or depths on the smooth drawing or fair sheet.

"Automation" places cartography on the threshold of the most revolutionary developments it has ever undergone. Electronic methods are steadily pushing seaward the frontiers of accurate hydrographic surveys and are making it feasible to explore the intricate patterns of deep coastal slopes with an accuracy and completeness undreamed of by the early methods—thus adding to the safety of life and property at sea and to the sum total of world geographic knowledge. However, any changes in charting must continue to take into account the basic purpose of the nautical chart to provide sufficient information for safe navigation while avoiding the possibility of confusion or misinterpretation.

New chart formats

The nautical chart is described as an instrument of

navigation designed to reflect the coastal geography and to show the depths of water, characteristics of the sea bottom, the location of dredged channels, reefs, shoals, and obstructions, landmarks, visual and electronic aids to navigation, and other information useful to the navigator. Scales generally range from 1:2,500 to 1:50,000 for harbour charts; scales of 1:50,000 to 1:100,000 are used for coastal navigation charts; scales ranging from 1:100,000 to 1:600,000 and smaller are for use in fixing the mariner's position as he approaches the coast from the open sea.

Inventions and innovations have always been compelling factors in U.S. Coast and Geodetic Survey charting programmes to meet the ever changing and expanding requirements of sea and air commerce. The explosive growth of recreational boating in the United States is the most recent phenomenon that has influenced the nautical chart design. The conventional chart is available to all boatmen, but the small boater has been handicapped by the limited space in the cockpit and inadequate storage space in his craft.

About 40 million people in the United States are involved annually in recreational boating. Approximately 8 million small boats and over one and one-half million boat trailers were estimated to be in use during 1962. The last estimate of outboard motors in use was in excess of six million and an additional 500,000 sailboats. This large and growing segment of U.S. population embraces the novice as well as the seasoned navigator, operating in all types and sizes of marine craft. To meet this need, a committee was appointed in April 1958 to study the problem and make recommendations for a compact chart for small-craft use in inland and coastal waters.

The new chart format resulting from this study represents the latest efforts in the design of the nautical chart to assure maximum usefulness to the greatest number of potential users. The scale and format for the charts are determined by the physical characteristics and boating pattern of the area to be charted. Four experimental formats covering the Potomac River were first designed in 1959 to conform to the majority of the requirements suggested by the boating public. These formats, during the successive five years, have progressed through the inevitable development evolution of modification until three basic designs have evolved.

The first type of small craft chart adopted is a folio of charts covering a concentrated boating area. The folio consists of either three or four pages measuring 14½ by 34 inches that have been accordion-folded and bound into a neat cover of maximum size of 8½ by 15½ inches when closed. The skipper has found this chart a pleasure to handle—regardless of close quarters or sea breezes. The multicoloured charts are published primarily at scales of 1:80,000 and 1:40,000 with large-scale insets of active harbour areas and for certain complex areas.

The standards of accuracy specified for compilation of the conventional charts have not been compromised in any way that would impair navigational safety. The boat operator is being provided with much more than just a chart in these folded editions. Within its protective wrap-around cover, the folio contains just about every thing the mariner needs to know, including annual tide tables, direction and velocity of tidal currents, information on marine weather service, and a complete tabulation of supplies and facilities keyed to the chart by numbers and location.

The second type of small craft chart under production is more of a route type chart. In recent years the largest market for intracoastal charts has been among the recreational boatmen. Moreover, in many areas, particularly along the Gulf coast, commercial traffic in the waterways has contributed substantially to the economic stability of many coastal communities. This commercial traffic requires charts specifically designed for navigation in congested waters.

The Intracoastal Waterway is a protected route, with some exceptions, for vessels navigating between Boston, Mass., and the Rio Grande, a distance of approximately 2,900 miles. Navigation is restricted, however, by the limiting depths which in some places is only 5 feet. Generally the project depth is 12 feet or more. Long canals have been cut through dry land in several areas such as the canals between Norfolk, Va. and Albemarle Sound, North Carolina.

More than 60 published intracoastal waterway charts rim the Atlantic and Gulf coasts of the United States from Norfolk, Va., to Brownsville, Texas. In reshaping these "route" charts, the U.S. Coast and Geodetic Survey considered both the commercial mariner and the recreational boatman. The new charts are nearly identical in scale and coverage to the old charts, but printed on sheet size 15 by 58½ inches. These sheets are also accordion folded to a compact size of 7½ by 15 inches, and inserted loose in a wrap-around cover on which the tides and facility data are printed.

Coastal areas such as in New England, Alaska, and most of the western coast of the United States are not readily adaptable to the format of the area or route type small craft chart. The mariner is primarily an offshore sailor, and traditionally noted for his nautical skill, but his craft is also limited in cockpit space for chart layout.

To provide a compact chart for these areas, the U.S. Coast and Geodetic Survey is publishing a third type of small-craft chart. Basically it is the conventional chart format printed on thinner high-wet-strength paper. It is subsequently folded once longitudinal and then accordion folded to a width of 7½ inches. A wrap-around cover with tide and current tables and facility tabulation has been added to make this a small-craft chart with the added feature that it can be opened up to the same size as the conventional chart if desired. The conventional chart of the same scale will be continued and published as a flat chart.

Conclusion

It might be summarized that all small-craft charts are similar in packaged size, content and utility for convenient use in limited cockpits and the exposed bridges of small craft. In the interest of boating safety, the charts will be revised and published annually as new editions.

This vital support to the safety of the citizens of the United States is made in conjunction with other functions of government that supervise the nation's sea lanes, provide lighting and buoyage for channels, and establish and maintain various aids to navigation. The essential public service of chart production and related activities compels constant alertness to increasing efficiency in progressive research for new means of better serving the chart user.

Many changes have taken place in hydrographic surveying and charting techniques during the bureau's long years of public service. Each new milepost in this steady march of scientific and technical progress has added more accurate and more detailed information to accumulated knowledge. Provisions are now being made for greatly enlarged efforts in solving problems through intensive oceanographic research programmes. These efforts will contribute their share to the future progress of the Bureau in coastal geography and nautical charting.

THE MEASUREMENT OF DISTANCES OVER WATER[1,2]

By Henry W. Bigelow, U.S. Naval Oceanographic Office

There is a fairly widespread belief that the tellurometer cannot, or at least should not, be used to measure distances over water. This belief may stem from the fact that a water surface may act as a reflector. A strong reflected ray will create a "swing",[3] and hence errors in measurement. Perhaps one should say "water swing". However, the more familiar term "ground swing" may be used no matter what the actual surface material. A water surface is not necessarily a good reflector and, therefore, not necessarily a source of error. This fact is attested to by engineers who have measured lines over water from the Bahamas to the Baltic and from Central Africa to Sarawak.

The reliability of measurements made across water becomes questionable when one or both of the terminals are located at a considerable elevation above the water surface. In figure 1-A the situation shown is where both terminals are at a considerable elevation above sea level. The angle of incidence (grazing angle) is large. The indirect (reflected) ray path is appreciably longer than the direct ray path. The indirect ray, however, may have about the same signal strength as the direct ray. This combination leads to excessive ground swing and unavoidable error in the distance measurement.

In figure 1-B the terminals are relatively close to sea level. The angle of incidence is small, and there is little difference between the lengths of the indirect and direct ray paths. In addition, much of the indirect ray signal strength may be dissipated in random reflections. This combination leads to little or no ground swing, and it does provide good measurement accuracy. The expression "considerable elevation" cannot be defined precisely, because the elevation must be considered in connexion with the length of the line being measured.

Even with the two terminals relatively close to sea level, the water surface conditions have an effect on the quality of measurement. Flat-calm sea conditions may produce anything from a rather weak, but readable signal to a completely unreadable display. If a light breeze picks up, it ruffles the water, breaks up reflections, and the display improves. If the sea builds up to a condition of choppy waves two or three feet high, conditions again become bad. The display is fuzzy, it varies in size, and it has an ill-defined break which is virtually unreadable. These are more or less general statements. In any given situation, the only real test is to try to measure the line. Conditions which are impossible at one time may prove feasible at another.

In 1961, geodetic survey parties of the U.S. Naval Oceanographic Office ran some 500 miles of tellurometer traverse through the central Bahama Islands. These traverse lines were almost exclusively over water. Many stations were sited on off-lying rocks, or on small cays. The greatest elevation did not exceed 130 feet. Closures on these lines were highly satisfactory, and no serious trouble was encountered in the measurements.

In September 1961, the Royal Danish Geodetic Institute made an interesting application of the tellurometer; they measured lines over water about 70 kilometres long. This was done by the line-crossing method. Two sets of tellurometers were used; the masters were installed in a vessel, and the remotes were located at the shore stations. Distances from the vessel to each shore station were observed simultaneously, while the vessel approached and crossed the line between the stations. The minimum distance, properly corrected, was compared with direct-distance tellurometer measurements from shore station to shore station. The mean difference between direct and line-crossing measurements was 18 centimetres.

Similar tests, using a Hydrodist installation, were made about the same time by the Swedish Hydrographic Department. In these tests the position of an off-lying island was determined by trilateration from three stations ashore. The island to island distances, varying from 42 to 57 kilometres, were measured by the line-crossing technique.

A fourth line about 90 kilometres long was attempted, but the line-crossing trial was not successful. Even though both terminals of the line were less than 45 metres above sea level, and thus well below the radio horizon, VHF radio telephone communication was established

[1] The original text of this paper, contributed by the United States of America, appeared as document E/CN.14/CART/66.

[2] Presented at the Joint Annual Meeting of the American Society of Photogrammetry and the American Congress on Surveying and Mapping, Washington, D.C., March 24-30, 1963.

[3] Ground swing is the variation in transit time during a measurement caused by stray reflections from objects in the microwave beam.

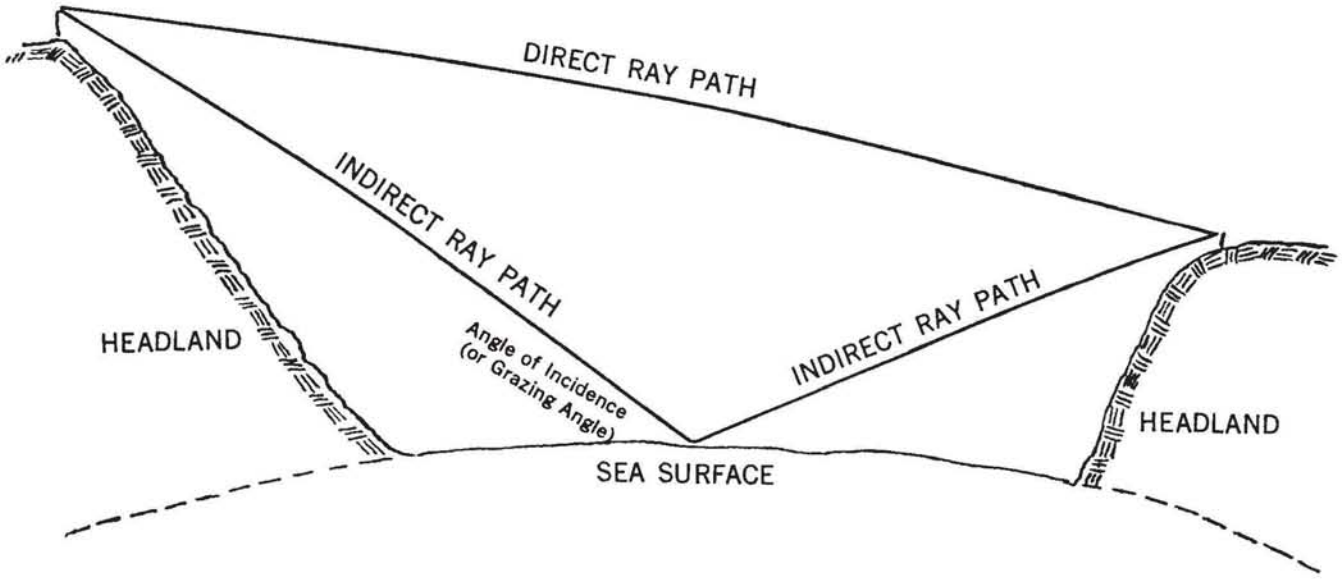


FIGURE 1-A—*Ray paths with elevated terminals*

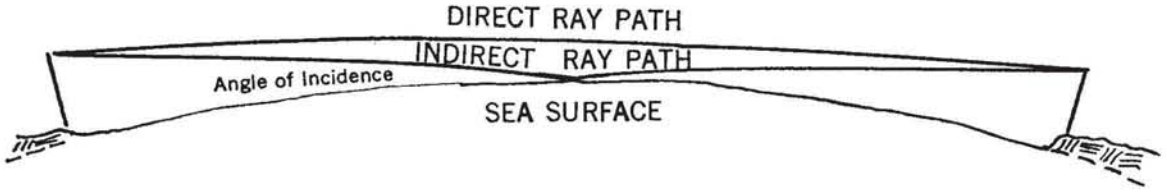


FIGURE 1-B—*Ray paths with low terminals*

between them. A master unit was rushed to one end of the line, and tellurometer distances were measured along the line. The probable explanation of this unusual measurement was the existence of a low-lying bank of thick fog just above the surface of the water and extending to the approximate elevations of the terminal stations. This condition must have created a tropospheric duct between the two terminals. The duct might also account for the lack of success in the line-crossing attempts. Efforts to repeat this measurement on succeeding days were not successful.

In this test, the three lines measured by line-crossing and the one line measured directly were included with the triangulation previously done in a rigorous adjustment. The position of the station on the off-lying island was determined with a radial standard deviation of ± 1.0 metre.

In May 1961 the Hydrographic Establishment of the British Admiralty made some tellurometer distance measurement tests from a fixed point on shore to a survey launch. These were quite successful with the launch either tied-up to a buoy or underway at speeds less than four knots. Errors on the order of one to two feet were reported.

For several years, the U.S. Naval Oceanographic Office has used Two-Range Decca and Decca/Lambda electronic positioning systems to control hydrographic surveys. Before operations commence these systems must be calibrated in order to remove fixed errors inherent in each pattern. To eliminate these errors, a distance must be measured from the electrical centre of the shore station to the electrical centre aboard ship. Until 1960, this measurement was done optically. Three theodolites were set up over known points on shore and a series of angles observed to position the ship by triangulation. About 12 hours of daylight were required to observe the angles necessary to fix the position of the ship at several points in the vicinity of one station. The computations occupied another 48 hours. To calibrate one ship at both shore stations often required four to six days.

To reduce this non-productive time, a new method of calibration was developed. In 1959 and 1960 experiments were made to check the feasibility of calibration by tellurometer. These experiments were successful and the new method was used in the calibration in the summer of 1960. Since then, this method has been used more than 20 times, each time with satisfactory results.

In addition to saving time, this method also saved manpower. It was possible to reduce the calibration party from four men to two. Time was not only saved in observing, but the computation time was drastically reduced. Because the tellurometer measured the desired distance directly, the only computation required was to translate the tellurometer travel time into the "lane count" of the phase meters for direct comparison. There were further savings because the tellurometer could carry on calibration during periods of fog or haze that precluded

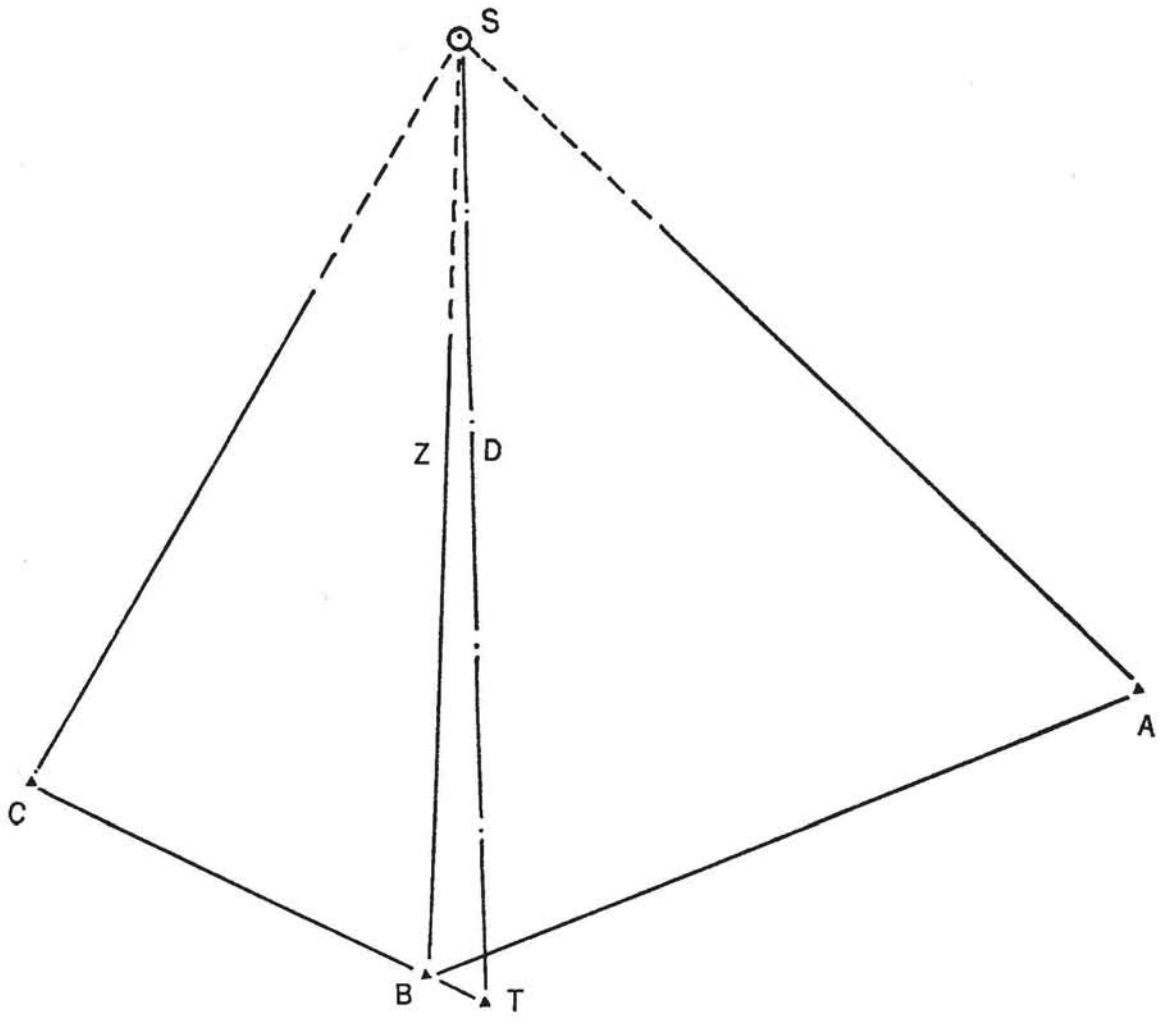


FIGURE 2—*Layout of test measurements*

The angles at A, B, and C are observed; The distance ST = D_T is measured by Tellurometer: The distance SB = Z is computed from each triangle and a mean value of Z used to compute D_C FROM THE EXPRESSION:

$$D_C = \sqrt{Z^2 + 9 - 6Z \cos(180 - B)}$$

The Tellurometer setup 3.00 metres from B on the extension of line CB. Line CB = 1,348.308 metres; Line AB = 2,391.487 metres.

visual work. The system can be calibrated with the vessel further out to sea. This advantage reduces inaccuracies from the effect of the land/water boundary on the low frequency signals.

The trails made in April 1960 were from a barge at anchor. The barge was positioned by sextant over a period of several hours. The distance from the barge to a station on shore was measured by tellurometer. The distance determined from the mean of the sextant was 1,232.8 metres $\pm$12.2 metres. As determined from a mean of the tellurometer measurement it was 1,236.1 metres $\pm$6.7 metres. This agreement was considered adequate. The standard deviation of 6.7 metres is equivalent to 0.016 Decca red lanes. This is about the same as the standard deviation of a Decca fix. Consequently these trials indicated the feasibility of Decca/Lambda calibration by this method. However, there is no indication of the real accuracy of the tellurometer measurements over water to a moving vessel.

To find out what kind of accuracy could be obtained between the shore and a moving vessel, tests were made in the Patuxent River, Maryland. The observations were made on 20 and 22 June, 1962 by a party from the U.S. Naval Oceanographic Office. The results were analysed by the writer.

Field observations were made with three azimuth instruments set up at convenient points on the shore. They were used to position a sounding launch by triangulation. The tellurometer master unit was in the launch. The remote unit was set up 3.00 metres eccentric from

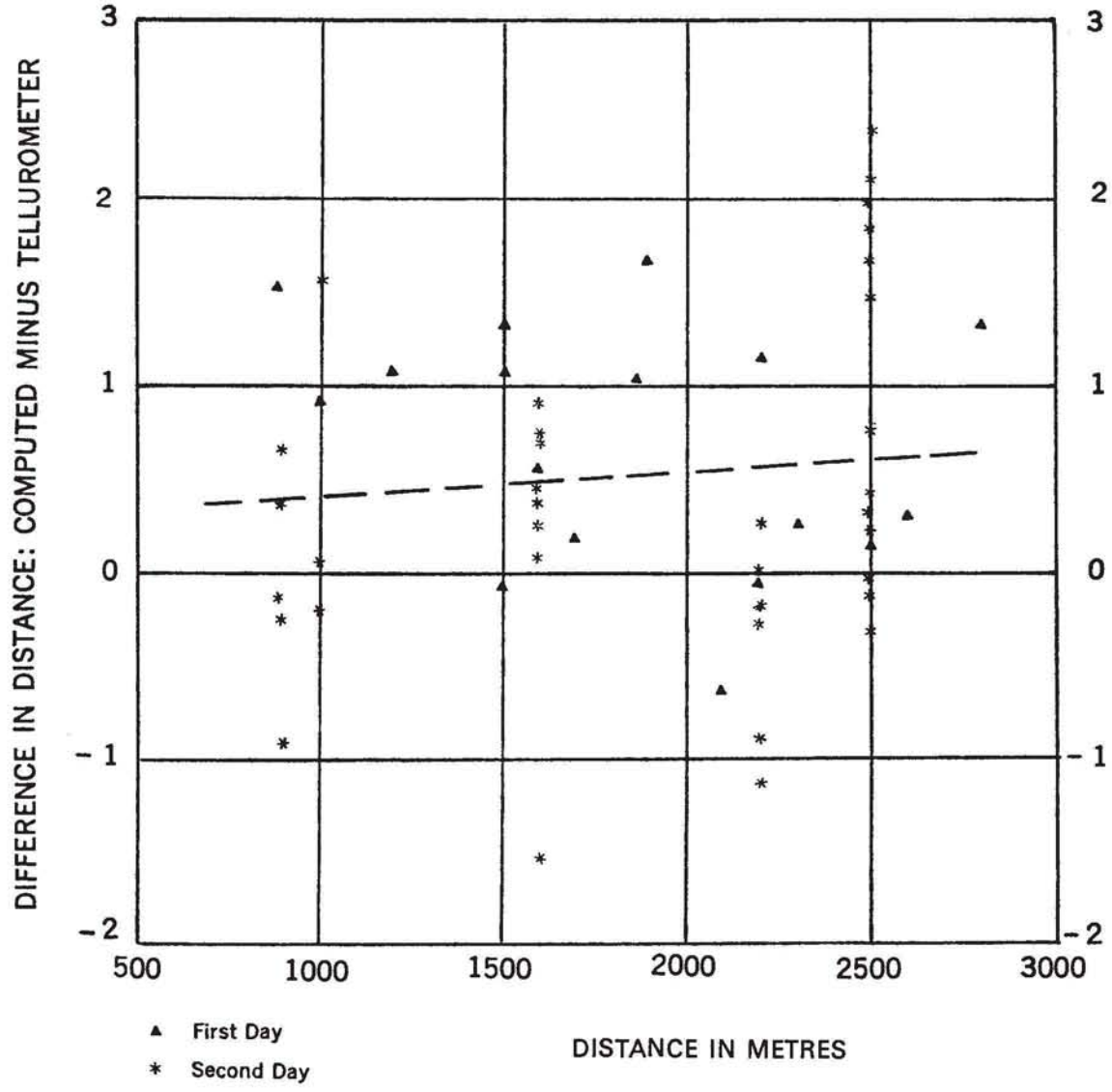


FIGURE 3—*Distribution of observations by distance*

the centre azimuth station. Figure 2 shows the layout of these test measurements.

At each fix, the angles were read to the sounding launch from the three stations. Simultaneously, the tellurometer readings were made in the same manner as had been used in the ship/shore calibration. The sequence of readings was *A*, *D*, *C*, *B*, *A*, and the difference between the first and last *A* readings was pro-rated for use with *B*, *C*, and *D*.

On these tests regular meteorological observations were not made, because of meteorological equipment troubles. Corrections for index of refraction were taken from bihourly data logged at the control tower of the Naval Air Station adjacent to the operation. In the usual ship/shore calibration meteorological data are taken on board ship only at the beginning and end of a series of observations. In observations made ashore it is customary to take the mean of observations made at both ends of the line. In the case of ship/shore measurements, the data at the ship end is considered to be more nearly representative of conditions existing over the entire water path.

In figure 2, the distance from *S* to *T* was determined in two ways: first, by direct tellurometer measurement, (D_T) and second, by computation, (D_C). The common side, *Z*, of the two triangles was computed from each triangle, and a mean value derived for each measurement. D_C was computed from the expression:

$$D = \sqrt{Z^2 + 9 - 6Z\cos(180\text{-}B)}$$

For each observation a D_C and a D_T are obtained. The most significant function of these two measurements is their difference. Therefore, the difference D_C minus D_T was derived from each observation.

A preliminary analysis was made of the data without correction for index of refraction. This analysis showed that some of the readings contained ambiguities. Some of these ambiguities could be resolved by the application of 100, 1,000 or 10,000 millimicroseconds. Ten observations were rejected. Two of these ten were rejected because an azimuth angle was missed; the other eight were rejected because of unsolved ambiguities. Ambiguities were resolved for nine observations. The mean difference, without correction for index of refraction, was found to be about 0.9 metre.

Table I. Analysis of differences in distance computed minus tellurometer
(Corrected for index of refraction)

	First day observations	*Second day observations*	*All observations*
Number of observations	20	42	62
Observations rejected	3	7	10
Observations used	17	35	52
Maximum positive difference	1.68	2.33	2.33
Maximum negative difference	0.65	1.54	1.54
Maximum spread of difference	2.33	3.87	3.87
Arithmetic mean of differences	0.691	0.369	0.474
Standard deviation of a single observation	0.630	0.907	0.723

A second analysis was made, after corrections for index of refraction had been included. Table I gives the results of this final analysis. It will be noted that the two days have been handled separately. This is because different operating procedures for the survey launch were used on the two days. On the first day, 20 June, the vessel maintained a more or less constant course and speed during observations. Speed was held to between two and four knots. The second day, 22 June, the launch was operated so that a series of observations were made with the launch laying to, after several observations the launch was moved to a new position. No observations were made during the runs between each series.

A plot of the recorded differences, distributed by the length of the line, is shown in figure 3. The observed differences were sorted by the computed distance into 100 metre groups 500 to 599, etc. Again a distinction has been made between the first and second day's work. The dashed line is drawn as a rough mean between the plotted points. Distribution of the points is believed to be random in nature.

Although the mean value of the second day's observations is lower, the spread of observations is much greater, and, consequently, so is the standard deviation of a single observation. From these data, it would appear that more accurate measurements are made when the vessel maintains a more or less constant course and speed during observations. Because it is impossible to stop a vessel, a predictable, consistent motion gives better results than a smaller, but purely random, motion.

In conclusion, two items should be stressed:

First: accurate tellurometer measurements can be made over water, if (*a*) care is taken to see that the terminal stations are not too high above the water surface, and if (*b*) the water surface itself is such as to minimize strong reflections.

Second: that measurements can be made from a fixed station to a moving vessel with a circular error of position of about 0.75 metre. If the usual meteorological corrections are not applied, the error will be higher than this value.

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AGENDA ITEM 14

Technical question on special mapping

(See also agenda item 6)

STUDYING THE LAND[1]

By Marion H. Baugh, U.S. Army Map Service, Washington 25, D.C.

In many world areas today, political leaders are showing an increasing awareness that sound economic planning should ideally be based on a detailed knowledge of the land. Conservationists, geographers, and agricultural planners have long had this awareness, of course, and, to a lesser degree, so have farmers, urban planners, and others who are concerned with relatively small parcels of land. But the concept that basic land knowledge is vital in planning the long range economic growth of an entire country has been slow in gaining acceptance on the higher political levels. This appears not to have resulted from a lack of perception at these levels, but rather from a necessary preoccupation with a variety of immediate problems, each seeming to call for unique and, above all, prompt solution.

Needless to say, there is a great variation among governments in their degree of acceptance of this principle that land study is a basic preliminary to good over-all planning. And when we take into account that a government may recognize the need for land studies and still not have available the necessary means to carry them out, we can readily understand the even greater variation among countries in actual application of the principle.

Enhancement of this admittedly modest awareness and application is ideally a task for teams of geographers, soil surveyors, and agricultural men. It is an important task, and the success with which it is carried out may well have a profound effect on the political and economic future of the world. One fact which should be helpful in this is the consistent record of beneficial returns in each instance of land study effort, no matter how small or how large the effort has been. Another point is that these results have been achieved in many instances from very small beginnings in terms of funds, materials, and skills for the work. A final observation—there appears to be no over-all "best" technical approach to the land study work. The approach can be made to fit the circumstances in each individual case.

A brief review of some of the land study work already accomplished will emphasize and illustrate the preceding observations. The examples have been chosen with the sole purpose in mind of demonstrating variety; there has been no attempt at comprehensiveness. And while many of you will recognize the examples as referring to your own work or that of an associate, specific mention of names will be omitted here.

Let us turn to a small tropical country, Puerto Rico, where dedication of the government to an ambitious programme of development plus the existence of much good basic information produced an almost ideal situation in which to make a complete land use and land classification survey as a basis for further planning. Few of us have this ideal situation to spur a programme, but we can all doubtless find ideas of value in it.

In the early 1950s, the Puerto Rican planning board, with a geographer as its chairman, determined that better knowledge of the land was necessary before logical and practical rural and urban development could be planned. Accordingly, a group of advisors, including both university and government personnel, was appointed. The first thing they did was to assess all available information. They found the following items covered the whole island: recent aerial photography, large-scale topographic maps, detailed large-scale soil maps completed in the 1930s, geologic maps, soil conservation surveys, and forest inventories. The thing that remained to be done in order to have complete background material for planning purposes was a survey of land use and a determination of land classification. Such a survey was needed as soon as possible, and was not contemplated as a long drawn-out study. It also needed to be economical. Yet there was much to do because the agricultural lands of Puerto Rico are densely settled. Graduate students, eager to participate for the experience which helped them to gain advanced degrees, were recruited from American universities. They provided professional help at a moderate cost. There were 18 teams of three university students each—two geographers with some background or training in field work in land utilization and one local person who knew the language and the area. The field programme was completed in two years, utilizing only the growing season months for various crops—7 months in each of the field mapping units—at a total cost of US $ 146,000. The area covered was 3,500 square miles. It was mapped at a scale of 1:10,000.

[1] The original text of this paper, contributed by the United States of America, appeared as document E/CN.14/CART/84.

This operation was assessed as "probably the most detailed survey of its kind in a tropical area of this size." As a result, the Puerto Ricans probably know more about their country than do the people of any other.

From what I have read, the productivity classification of Hawaii's agricultural lands, now in progress, is in many ways similar to the Puerto Rican survey.

Taiwan, several times larger than Puerto Rico and with a different set of circumstances, has approached its problems in land study in a somewhat different way. Interestingly enough, however, governmental and university people here also have joined forces to accomplish its objectives.

An over-all land use and forestry survey was the first step taken in Taiwan, and this was accomplished prior to 1953. A more detailed land capability survey—started in 1953 and perhaps by now accomplished—was then initiated for the marginal zone between crop and forest land.

The forest resources survey determined the distribution of forest types and the volume of timber available. It was based on aerial photography and field survey. Sample aerial photography at large scale was used to study forested areas in the mountains where access was difficult. The land use survey was accomplished by the economical method of mapping in the field in sample areas using aerial photography and establishing photo keys. The land use of the major part of the area was then interpreted from aerial photography, using the established photo keys. The final maps show the results of both the forest and land use surveys; they depict forest types and volume, land use, and problem areas.

The printing of the final maps from this survey at a scale of 1:50,000 was not costly. Forest and land use information was overprinted on existing stock of topographic map sheets. This not only eliminated the expense of making base maps and the expense of paper for printing, but having the land use overprinted on the contoured maps made the information infinitely more valuable for study and planning than would have been the case had the land use material been printed alone.

The land capability survey, underway since 1953, is a survey in the field of the problem areas—the marginal areas between crop and forest land—which were highlighted as a result of the original surveys. Five teams are in the field making this survey, and specialists on soils, agronomy, horticulture, forestry, and animal husbandry are available when needed.

The objective is to establish definite uses for each part of the marginal area, such as for crops, orchards, grass, or forests. The classification system used is that of the U.S. Department of Agriculture. Again on this survey aerial photography is being used, but it is of more recent date than that of the land use and forest surveys and at a larger, more suitable scale—1:20,000.

One cannot help but feel that Taiwan will be taking a great step forward when planning, based on these surveys, is implemented.

An entirely different approach to land use mapping has been taken in Italy, another area where much necessary information was available. This information was in an entirely different form from that in Puerto Rico or Taiwan, and it has eliminated even the need for field work or for air photo-interpretation. Large-scale topographic maps covering all of Italy depicted vegetation by symbols in great detail; these maps were based on field-checked aerial photography. Their existence is doubtless due to a long history of excellent and detailed map making on the part of the Italians. To get the pattern of land use from these maps it has been necessary simply to group together by common colour the areas showing the same vegetation types. This results in a map showing land use in a pattern readily discernible to the eye.

The land use map thus produced relies entirely upon the topographic map for field accuracy. This method is perhaps not so well adapted to most other parts of the world because vegetation information is not generally depicted in such detail on topographic map sheets even though it may have been taken from field-checked photography. The Italian land-use maps, incidentally, are published by the Touring Club of Italy on their excellent series of base maps at a scale of 1:200,000.

In a number of areas—Hong Kong and Ceylon, to name only two—a time-saving and money-saving technique much like that used for the land use survey in Taiwan is being put to work. Much of the analysis of land use and land classification is based on aerial photo-interpretation, but sufficient field work is done to provide a reasonably accurate photo-interpretation key. In Ceylon, these are considered reconnaissance surveys and are expected to indicate areas in which intensive surveys should be made for planning the development of the island's resources. Such surveys can be accomplished by a small group of photo-interpreters, with the work extending over a period of several years.

With respect to Hong Kong, the land use survey work brought into focus an important factor already stressed in connexion with Puerto Rico—the value of checking to see what pertinent information has already been gathered. The group on Hong Kong discovered excellent and very helpful cadastral surveys, of which they had not known before, which had been produced by the Department of Agriculture. As the report on the Hong Kong survey states, the value of bringing together the different types of surveys and also of utilizing social and historical facts as well as a knowledge of geology, topography and climate cannot be overstressed; all must be considered for the understanding of land use and planning for improvement. Here again the talents of university and government were combined and the project completed in a relatively short time.

Less densely settled lands lend themselves to more rapid survey than the more densely settled ones we have considered thus far. Trained personnel can, in a short time, survey the less intensive land use and accomplish some land classification. The land use studies in the Transvaal Loewveld in South Africa demonstrate this. One member of a university faculty, with the help and advice of a number of specialists, completed the survey of an area larger than Puerto Rico in two field seasons. Existing land utilization was mapped mainly on large-scale field maps made by enlarging

existing 1:50,000 topographic maps. Where no topographic maps existed, aerial photos were used as bases for plotting information, with the final map being a planimetric presentation. Crop information was collected from each farm, and crop distribution maps prepared. The opportunities of the area for crop-producing were appraised. A survey such as this costs relatively little and contributes a good deal as a basis for planning.

In the early 1950s, Northern Rhodesia, with little in the way of accurate detailed topographic mapping and only highly generalized soil maps to go on, started to develop, almost from scratch, land use and land capability maps in a wide strip in the eastern part of the country. These maps have proved to be highly successful for regional conservation planning according to reports. Here again, aerial photography has been used. From the photographs, rough planimetric maps have been made. In the field, men trained in conservation add data on existing and proposed dams and irrigation projects, soil types or capabilities, and land use. When a considerable area has been covered, modifications of land use and the construction of new dams and irrigation canals are suggested and plotted on large scale plans for direct use by individual farmers. At the rate of about 775 square miles per year, they expect to complete the job in ten years.

West New Guinea, at the other end of the scale from small, densely settled Puerto Rico, resorted to a sample survey to obtain land classification information in a very short period of time. New Guinea is large (160,000 square miles or 416,000 square kilometres) and access is difficult. There are virtually no roads except in the vicinity of the coastal towns. It is natural then that they turned to the sample survey.

In carrying out the work, aerial photography was scanned for all types of land and enough sample areas chosen so that the samples could be considered representative of the whole. The sample areas were studied in some detail in the field and information extended by photo-interpretation to other similar areas. Although this type of survey is far from ideal, it has certain advantages. For example, if sample areas are carefully chosen and are representative of each part of the country, then much knowledge can be gained at a very low cost per unit of area. This is especially important in large areas such as New Guinea, where size alone is a formidable obstacle. Another advantage is that the time necessary for a sample survey is only a fraction of what a complete survey would require.

This has been an all-too-brief survey of just a few of the many countries which are seeking to know better their land and its potential. It does, nevertheless, point up a number of interesting facts for the consideration of all who are making or contemplating surveys;

1. Explore possibilities for the best prepared advisors and workers. A combination of university and government minds working together seems to produce excellent results.

2. Take stock to learn what survey material is available from every conceivable source. You may have some pleasant surprises.

3. Military agencies as well as civilian may have helpful materials.

4. Aerial photography is invaluable whether or not other materials are available.

5. If political leadership needs to be convinced on the contribution which land study may make, select carefully a problem area where you think planning would be most obviously aided by survey material. Even a small start, if it is in the right place, will make the desirability of a survey obvious.

6. The World Land Use Survey Commission of the International Geographical Union was working most effectively towards the satisfaction of national need the world over when it undertook to devise standards for land use surveys. We can only encourage all concerned to support this work completely.

The countries of Africa are alert to the need for land study; many of them according to reports of the International Geographical Union have started, at least in small areas, to map the manner in which their land is used.

Nor have they been altogether idle in the fields of topographic mapping and air photography. They have, therefore, a substantial start for enlarged land study programmes. Most important of all is the awareness and interest which has developed, for with this a country can devise a plan, either simple or more complex, adapted to its own situation.

(See also agenda item 6)

FRENCH PARTICIPATION IN THE BOTANICAL CARTOGRAPHY OF FRENCH-SPEAKING WEST AFRICA[1]

By Jean-L. Trochain, Professor in the Faculty of Sciences, Toulouse, Director of the Third Biogeographic Cycle

From the beginning of the nineteenth century, after the sensational explorations of the "equinoctial regions" by A. de Humboldt, founder of the explanatory method of biogeographic phenomena, the Danish botanist Schouw, with remarkable perspicacity, recognized the phytogeographic applications to the economy. He wrote:

> "A good botanic map can often give a more comprehensive view of the productive capacity of a country and its growth potential than many statistical tables. An exact knowledge of the connexion between climate and vegetation obviates much useless expenditure". [5][2]

One hundred years later, however, at the beginning of the twentieth century, the ministerial administrative authorities failed to recognize the value of the masterly graphic syntheses of Ch. Flahault, who covered one-tenth of the area of our country; and it was not until 1948 that the French Government in its official report to OEEC, attached "a very special importance to the development of technical research and the dissemination of modern methods of both production and work organization". [5]

The continuing growth of the world's population places the question of agricultural output in the first rank of world preoccupations, both in the rich, developed countries and in the under-developed or backward countries of the *tiers monde*.

More often than not better cultivation means replacing natural primitive vegetation by another, economically more rewarding vegetation, to which man gives all his attention.

Natural vegetation provides exhaustive lessons on the environmental conditions of which it is the reflection. It is, therefore, essential for agriculture that this ecology should be known. "Wild" vegetation, in the words of Ch. Flahault, gives "to anyone who can read, the most specific information about the possibilities of human expansion".

It was rational to try and synthesize, by means of the cartographic method, these connexions showing the dependence between environment, vegetation, and agricultural potentialities, in order to put them within the reach of all users.

> "Phytogeographic maps are a veritable tool of production: they are, for the utilization of the mass of vegetation what the geological map is for the working of the riches of the sub-soil". [5]

Much patient analytical work is necessary, however, before reaching this synthetic stage, certainly of great economic interest; work on the flora is, in particular, indispensable. It may make possible the preparation of flora maps, which are therefore a stage in acquiring knowledge about the vegetation but which, for some may also be an end in itself, of essentially scientific interest.

There is therefore a difference between flora and vegetation. [12]

The flora of a region is the list of the plant species to be found there: all plants are mentioned in the same way, irrespective of their abundance. The existing flora is the reflection of a long and distant past.

The vegetation of a region is its vegetative cover. It is formed of species of the flora grouped in various quantities and proportions, some playing a considerable role and the others being disseminated, and seemingly lost, among the first.

The history of vegetation is recent. The vegetation may be luxuriant and the flora relatively poor (Beech forest); the soil almost barren and the flora relatively rich (Sahara).

1. Flora maps

This type is generally, and wrongly, referred to as a botanic map *sensu stricto*. It corresponds to the representation of results obtained by the discipline for which the name plant geography should be specially reserved.

Two procedures may be distinguished:

The area map, or map of systematic units;

The map of flora units.

The area map, or map of systematic units: if the places where a given plant has been gathered, or its presence indicated, are pricked on a topographic map and if the outermost pricks thus obtained are joined together by a continuous line, if, in short, the line enveloping the places is drawn, the area of the plant under consideration is mapped.

In this way it is possible to materialize the area of a species, a genus, a family... of any systematic unit.

A German publication, "Die Pflanzonareale", was devoted to these questions and many examples could be borrowed from taxonomic works.

The boundaries thus drawn may be governed by biological conditions, and it is in this way that the boundary of the Olive-tree Area has often been taken as

[1] The original text of this paper, submitted by France, under the title "La participation française à la cartographie botanique de l'Afrique francophone de l'ouest," appeared in French, as document E/CN.14/CART/12 and Add.1.

[2] Figures in brackets relate to the bibliography.

the boundary of Mediterranean countries in Western Europe.

The many diagrams appearing in the various works by A. Aubreville noted under Nos. 1 and 2 in the bibliography provide an excellent example in western Black Africa. Mention could be made of many other authors, such as Th. Monod [10], who have illustrated their works on African flora with sketches (a term preferable to map in this context).

The area boundaries of cultivated plants, or plants of economic interest, have often been mapped. I shall, as examples, mention:

Les cartes économiques de Meunier pour l'ex-A.O.F. (Meunier's economic maps for ex-French West Africa)[9];

Les cartes économiques de la Direction du plan pour l'ex-A.E.F. (the economic maps of the Department of the Plan for ex-French Equatorial Africa) [6];

The economic maps of French West Africa and French Equatorial Africa which appear under Nos. XVIII and XXIII in the *Atlas des colonies françaises* (atlas of French Colonies), Paris, Soc. d'éditions, 1934;

La carte économique de la région Chari-Lac Tchad by Aug. Chevalier (the economic map of the Chari-Lake Chad Region) [4];

Aire de l'Okoumé (marchés coloniaux, No. 270, 1951) (Okoumé area (colonial markets, No. 270, 1951));

Aire du Kapokier, du Karité et du Gommier au Soudan (Mali, on the scale approximately 1:6,400,000) Agro. Trop. VII, 4, 1952 (area of kapok tree, shea tree and gum tree in the Sudan (Mali, on approximate scale 1:6,400,000) (Agro. Trop. VII, 4, 1952)).

The map of flora units: if the boundary areas of a great number of plants are superimposed on one and the same map it will be seen that many of them cover the same regions. Thus are delimited territories of greater or less extent, characterized by the co-existence of a whole flora aggregate.

A certain order is therefore apparent in the spatial distribution of systematic units, although the area of each, considered separately, has not been acquired under the sole influence of existing circumstances and reference must be made to its history and the migrations it has suffered.

The fact, however, is there: because privileged regions have been the centres where species were formed or whence they were dispersed, there are comprehensive groups to which floral names have been given: Euro-Siberian flora, paleo-tropical flora.

It should be noted straight away that representatives of the characteristic flora are not the only flora to be found in a "dition".[3] It is possible that there are survivals from former occupants; the neighbouring "ditions" may have sent migratory currents. There are thus many superimposed flora but the most numerous is chosen to characterize, florally, the territory under consideration.

[3] Dition: territorial surface considered in absolute value, independently of any biologic, ethnographic, administrative subdivision or any other kind of subdivision.

To illustrate this paragraph, I shall mention Th. Monod with his 1:34,000,000 map of the phytochorologic divisions of Africa [11] and A. Aubreville who, in his *Flora of Gabon* has given a sketch of flora territories.[3]

These representations are inevitably more subjective than those on areas because personal interpretation plays an important role. It is not surprising, therefore, that the boundaries, drawn by different authors, do not exactly tally with each other. The terms themselves, particularly Floral Empire and Floral Region, are not universally accepted or do not respond to the same definition.

The important thing here is rather to understand the spirit in which these maps are prepared than to measure the differences of interpretation which may separate them.

Moreover, flora and vegetation are very closely intertwined on the ground: although their history is different they in fact depend on each other. Flora does not exist in the pure state, as if disincorporated: it becomes reality only through the plants whose existence is subject to all the constraints of the environment. It is not surprising, therefore, to note that in West Africa the boundaries of floral units are often those of phytogeographic territories and of types of vegetation about which we shall now speak.

2. Vegetation maps

Their purpose is to give material boundaries in space to:

(A) The phytogeographic territories each characterized by their climate, flora and vegetation;

(B) The types of vegetation [13] and the vegetal groupings distinguished on the land.

(A) *The boundaries of phytogeographic territories of West Africa:* this concern to show in material form on maps of various scales the division of West Africa, wholly or partly into territories characterized by their vegetation was the very first undertaking of phytogeographers but it is by no means finished.

Without trying to compile an exhaustive inventory or wishing to refer back to the work of precursors (Grisebach 1872, Drude 1897, Schimper 1898, Engler 1910), and limiting myself to French authors, I shall mention:

1912—Chevalier (Aug.), Carte botanique, forestière et pastorale au 1/3.000.000 de l'A.O.F. (botanic, forestry and pasture-land map of French West Africa on the scale 1:3,000,000). *La géographie*, Paris, XXVI, No. 4.

1924—Mangin (C.), Esquisse forestière de l'A.O.F. au 1/3.000.000 (forestry outline on scale 1:3,000,000 of French West Africa). *La géographie*, Paris XLII, Nos. 4 and 5.

1933—Chevalier (Aug.), Carte géobotanique au 1/3.000.000 de l'ouest africain (geobotanic map on scale 1:3,000,000 of West Africa). *Bull. Soc. Bot. France*, LXXX.

1934—Hubert (H.), Les zones botaniques en A.O.F. au 1/3.000.000 (botanic zones in West Africa on scale 1:3,000,000). *Atlas des colonies françaises*, Paris, Soc. d'éditions.

1936—Aubreville (A.), Types de forêts et courbes pluviométriques de la Côte d'Ivoire au 1/12.000.000 (forest types and pluviometric curves of the Ivory Coast on scale 1:12,000,000) *in* Flore forestière de la Côté d'Ivoire, Paris, Larose et *ibid.*, 2nd ed., 1959.

1937—Aubreville (A.), Croquis des formations forestières du Togo-Dahomey (sketch of forest formations in Togo-Dahomey). *Bull. Com. et Hist. et Scientif.*, A.O.F., xx, No. 1 et 2.

1940—Roberty (G.), Contribution à l'étude phytogéographique de l'A.O.F., (contribution to the phytogeographic study of French Africa). *Candollea*, Genève, VIII, pp. 83-137, une carte.

1948—Aubreville (A.), Croquis de la végétation forestière actuelle et ancienne (de l'Oubangui-Chari, du Tchad et du Cameroun). Étude sur les forêts de l'Afrique équatoriale française et du Cameroun (sketch of present and former forest vegetation (of Oubangui-Chari, of Chad and Cameroun). Study of the forests of French Equatorial Africa and Cameroun). Publication de la Direction de l'Agriculture, de l'Élévage et des Forêts, Ministère de la FOM, Bull. No. 2, p. 92.

1949—Richard-Molard (J.), Les climats et les milieux naturels (en A.O.F.). Un croquis schématique (climates and natural environments (in French West Africa)). A schematic sketch *in* AOF. Coll. *Union française*. Berger-Levrault, Paris, p. 41.

1949—Pitot (A.), A.O.F., répartition de la végétation (French West Africa, distribution of vegetation). Encyclopédie coloniale et maritime, T.I., Paris, p. 81.

1949—Aubreville (A.), Forêts claires en Afrique tropicale au 1/40.000.000 (sparsely wooded forests in tropical Africa on scale 1:40,000,000) *in* Climats, forêts et désertifications de l'Afrique (climates, forests and desert lands of Africa), p. 255—Société d'Éditions, Paris.

1949—Aubreville (A.), Aire actuelle et ancienne des forêts d'Afrique tropicale au 1/40.000.000 (present and former forest area of tropical Africa on scale 1:40,000,000). *Ibid.*, p. 206.

1952—Schnell (R.), Subdivisions géobotaniques de l'ouest africain au 1/7.000.000 (geobotanic sub-divisions of West Africa on 1:7,000,000). *Mem. I.F.A.N.*, No. 18.

1954—Trochain (J. L.), Les territoires phytogéographiques de l'Afrique de l'ouest au 1/40.000.000 (the phytogeographic territories of West Africa on scale 1:40,000,000). *Naturalia*, Nos. 6 and 7.

1959—Aubreville (A.), Types de végétation de la Côte d'Ivoire au 1/4.500.000 (types of vegetation of the Ivory Coast on scale 1:4,500,000) in Flore forestière de la C.I., Centre technique forestier tropical, Paris, p. 19.

(B) *Mapping of vegetation groupings:* the purpose of these maps corresponds more precisely with the aims stated in the introduction to this report, for they will, as has been said, materialize in terms of space, the reflection of environmental conditions.

There is no objection—in fact quite on the contrary—to them indicating also on a suitable scale the distribution of spontaneous vegetation and the present use of land (crops, forests, pasture-land). Even more, by graphically translating the environmental conditions which authorize this spontaneous vegetation, they should permit deductions on the potential use and nature of the soil and guide experiments.

Their practical worth by thus supplying a picture of what is and what could be with respect to the rational development and better use of the soil, the substitution of the present vegetation by another more remunerative or more desirable, and the inventory of vegetal forestry and agricultural resources cannot be denied.

The scale used to meet this utilitarian concern should be greater than 1,000,000. Smaller ratios only provide outlines permitting general views and the preparation of larger scale maps. The following works come into this category:

1950—Jacques-Felix (H.), Formations végétales du Cameroun à l'échelle du 1/7.000.000 (vegetal formations of Cameroun, on the scale of 1:7,000,000).

1958—Mangenot (G.) and Miege (J.), Esquisse botanique de la Côte d'Ivoire (échelle: 1/2.500.000) (botanic sketch of the Ivory Coast (scale 1:2,500,000)). *Actes du Coll.* de Kandy, publ., UNESCO, Paris.

1959—A.E.T.F.A.T.: Carte de la végétation de l'Afrique au sud du tropique du cancer (au 1/10.000.000) (vegetation map of Africa south of the Tropic of Cancer (on 1:10,000,000)) University Press, Oxford.

1961—Letouzey (R.), Carte phytogéographique du Cameroun (au 1/2.000.000 (phytogeographic map of Cameroun (on 1:2,000,000)) in *Atlas of Cameroun*, IRSC, Yaoundé.

It is on the scale of 1:1,000,000 and even better of 1:200,000, or larger scales, that African phytogeographic maps can be of assistance to non-botanist users.

The titles of many appear in the appendix to this report because they were conceived or designed by a team under the leadership of Professor H. Gaussen [7]. They are:

1950—Roberty (G.), Gaussen (H.) and Trochain (J. L.), Carte de la végétation de Thiès (Sénégal) au 1/200.000 (vegetation map of Thiès, Senegal, on scale 1:200,000). ORSOM, Paris.

1953—Roberty (G.), Carte de la végétation de Bouaki (Côte d'Ivoire) au 1/200.000 (vegetation map on scale 1:200,000 of Bouaki (Ivory Coast)). ORSOM, Paris.

1955—Roberty (G.), Carte de la végétation de Diafarabé (Mali) au 1/200.000 (vegetation map on scale 1:200,000 of Diafarabé, Mali). ORSTOM, Paris.

Other cartographical works besides those produced by the Institut de la carte internationale du tapis végétal have been successfully completed. They are:

1956—Roberty (G.), Carte de la végétation de Louga (Sénégal) au 1/200.000 (map of the vegetation of Louga (Senegal) on scale 1:200,000). ORSTOM, Paris.

1959—Derbal (Z.), Pagot (J.) and Lahore (J.), Carte botanique (des terrains du centre de recherches zootechniques de Bamako-Lotuba) au 1/20.000 (botanical map of the grounds of the Zootechnical Research Centre of Bamako-Lotuba on scale 1:20,000). Bureau des sols de l'A.O. Paris, Vigo publishers.

1961—Koochlin (J.), Esquisse de la végétation au 1/1.000.000 *in* la végétation des savanes dans le sud de la République du Congo (Brazzaville) (outline of vegetation on scale 1:1,000,000 in Savannah vegetation in the south of the Republic of Congo (Brazzaville)). IRSC. Brazzaville.

It should perhaps be pointed out that at Toulouse the work on vegetation maps is carried on in collaboration by three organizations which work in a pool in pursuance of a single set of common principles.

Le service de la carte de la végétation de la France au 1:200.000 (the service for the vegetation map of France on scale 1:200,000), which is a branch of the CNRS (National Scientific Research Centre) and directed by Mr. P. Roy.

Le troisième cycle de biogéographie (The Third Biogeographic Cycle), which comes under the Faculty of Science and which is directed by the author of this report.

L'Institut de la carte international du tapis végétal (The Institute of the International Map of Vegetation Cover) which is directed by Professor H. Gaussen.

If I mention him last it is that I may be better able to

pay him tribute for he is the originator of the cartographic method followed at Toulouse and is the founder of the three above-mentioned organizations, the first two of which are directed by two of his pupils.

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9. Meunier (A.), Cartes économiques de l'AOF au 1/3.000.000 Cultures alimentaires, fourragères et médicinales. Paris, 1922.
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WORK ON AFRICA DONE BY THE INSTITUT DE LA CARTE INTERNATIONALE DU TAPIS VÉGÉTAL

By F. Bagnouls

The mapping of the vegetation and climatic regions of Africa and other overseas countries is done at the Institut de la carte internationale du tapis végétal (Institute of the International Map of Vegetation Cover) whose laboratories are at the Faculty of Science, Toulouse.

The Institute, which was established in 1960, is directed by Professor H. Gaussen who had previously been Director of the vegetation mapping service of the CNRS.

1. Vegetation maps of Africa

Some are made on the scale of 1:200,000, others on the scale of 1:1,000,000.

The principle adopted for the representation of vegetation is that developed by H. Gaussen:[1] the colour represents environmental conditions, the way in which the colour is applied represents the types of vegetation. Thus, for example, starting from the convention that red represents intense heat and blue a high rate of humidity, the maps depict equatorial vegetation in violet (red + blue) and desert vegetation in red. The way in which the colour is applied indicates the formation of the vegetation: flat tints indicate forest while small dots indicate "erme", i.e., sparse herbaceous vegetation. Between these two extremes, savannah land, wooded savannah land, etc. are marked by dashes or checks. The maps of Africa already published are:

On the scale of 1:200,000

Morocco: Rabat-Casablanca
Algeria: Oran, Bosquet-Mostaganem, Guelt-es-Stel-Djelfa
Sahara: Beni-Abbès
Ivory Coast: Bouaké
Sénégal: Thiés
Mali: Diafarabé
} in collaboration with ORSTOM

On the scale of 1:1,000,000

Tunisia and East Algeria: Tunis-Sfax
Sahara: Faya-Largeau (being printed)

Maps in course of preparation are:

On the scale of 1:200,000

Algeria: Algiers, Tlemcem-Lebdou
Morocco: Mazagan

On the scale of 1:1,000,000

Algeria: Algiers-Laghouat (a continuation of the Tunis-Sfax sheet)
Cameroun: complete map in two sheets
Madagascar: complete map in three sheets

2. Bioclimatic maps

The purpose of bioclimatic maps is to indicate the biological climate.[2]

Climate classification is based essentially on periods favourable or unfavourable to vegetation, i.e.: dry periods; semi-dry periods; wet periods; hot periods; cold periods; a month is dry when $P \leqslant 2T$: P total precipitation in

[1] H. Gaussen—Projets pour diverses cartes du monde au 1:1,000,000; la carte écologique du tapis végétal (projects for various world maps on the scale of 1:1,000,000; the ecological map of the vegetation cover) International Geography Congress, Lisbon 1949.

[2] F. Bagnouls and H. Gaussen—Saison sèche et indice xérothermique (dry season and xerothermal index). Bull. soc. his. nat. Toulouse, t 88, pp. 193-239. Toulouse 1953. F. Bagnouls and H. Gaussen—Les climats biologiques et leur classification (biological climates and their classification). Ann. geogr. bull. soc. geogr., pp. 193-220. Paris 1957.

millimetres; T average temperature in degrees centigrade).

The dry period is the successive continuation of dry months.

A month is semi-dry when $2T < P < 3T$.

A month is wet when $P > 3T$.

A month is hot when $T > 20°$.

A month is cold when $T \leqslant 0°$.

Between 0 and an average of 20° the month may be warm temperate, mean temperate, cold temperate.

In Africa the principal climates are differentiated above all by the length and intensity of the dry period. If the dry period occurs in summer the climate is of the Mediterranean type; if it occurs in winter the climate is tropical.

Published bioclimatic maps[3]

On the scale of 1:5,000,000

Map of Mediterranean regions: from Portugal to the Indus in longitude and from the 12th to the 44th degree of latitude. This map contains, therefore, all the arid parts of Africa north of the equator, of the Near East and of the Middle East.

On the scale of 1:10,000,000

South Africa (south of the 20th degree).

On the scale of 1:500,000

Rainfall map for Algeria, Tunisia and Morocco. Unpublished map.

On the scale of 1:10,000,000

The whole of Africa.

3. OTHER WORLD MAPS

Published vegetation maps

On the scale of 1:1,000,000

Cape Comorin and Madras (India).

In preparation:

On the scale of 1:1,000,000

South India, New Caledonia.

On the scale of 1:200,000

Society Islands.

Published climatic maps[4]

On the scale of 1:10,000,000

Western United States of America
Southern Australia
Southern part of South America.

Unpublished maps

On the scale of 1:10,000,000

South America
North America
Russia and Siberia.

[3] UNESCO-FAO: bioclimatic map of the Mediterranean area Recherches sur la zone aride, Paris 1963.

[4] UNESCO-FAO: bioclimatic map of the Mediterranean area. Recherches sur la zone aride, Paris 1963.

VEGETATION MAP, A PROBLEM OF SCIENTIFIC RESEARCH[1]

By Professor Dr. P. Rey, Directeur du Service de la carte de la végétation au Centre national de la recherche scientifique (France). (Director of the Vegetation Map Department at the National Scientific Research Centre (France))

Among the topical maps that it is possible to produce of a territory already endowed with an adequate topographical base, maps showing vegetation cover assume an increasingly acknowledged importance.

The systematic mapping of vegetation, which has been carried out in various parts of the world, and more specially in France, reveals today the threefold importance of this type of work: botanical maps are proving more and more necessary as for the purpose of factors in *description*, *interpretation* and *decision*.

Their success, however, is a warning, for the production of such maps might be dangerous in the absence of a constant scientific supervision over their preparation, reading and utilization.

THE MAP AS A FACTOR IN DESCRIPTION

The first result that we are entitled to expect from a vegetation map is a record of the present state of vegetable growth, resulting from the combined action of environmental factors and human influence.

This operation of statistical census-taking seems today all the simpler in view of the fact that aerial photography constitutes an aid to investigation of the first importance in this field, to such an extent that it would henceforth appear unreasonable to undertake the botanical cartography of a territory, even on a small scale, before ensuring its coverage by aerial photography.

In fact, however, and precisely by reason of those very facilities provided by photographic interpretation, we see that there is a vast production of maps concerning vegetable-cover produced by non-specialists, in addition to those produced by phytocartographers. Vegetation, indeed, possesses the dangerous privilege of constituting an element, whether, direct or indirect, in a very large number of disciplines. Less than five per cent of the surveys relating to botanical photographic interpretation are written by botanists. And yet the majority of these texts conclude that proper specialization is necessary in order to guarantee correct photographic interpretation.

This is at once an honour and a danger for phytogeographical science, as it is quite obvious that botanical

[1] The original text of this paper, submitted by France, under the title "La cartographie de la végétation. Problème de recherche scientifique," appeared in French as document E/CN.14/CART/13.

cartography must be a matter for specialists, exactly like other types of topical cartography: what is accepted for archaeology, geology, rural economy, forestry or the military arts, is at least as necessary for phytogeography, particularly when description is intended to lead to application.

The map as a factor in interpretation

The effort involved in phytocartography, indeed, like all other forms of cartographic effort, appears relatively heavy. It is only fully justified to the extent that it engenders new explanations or opens up new prospects of research.

Now, experience has shown that all the phytocartography systems produced in the world by phytocartographers, and interpreted by them, always achieved positive results in the shape of improved knowledge of the natural environment of a territory, and of the relationships manifested between the climate, the soil, life, man and time.

The various "schools" of phytocartography, in spite of differences in doctrine which for too long apeared to be contradictory whilst in reality they were complementary, to each other permit a more or less thorough application of these five biogeographical dominants in different degrees according to the varying relevance of the principles applied and the scale adopted to express them.

All of them, however, have in common the rigourousness of scientific control and the aim of placing fundamental research in the forefront, where it belongs, so as to provide better guarantees for the possibilities of application in the different sectors of the economy.

The map as a factor in decision

The third aspect of botanical cartography implies that the record duly *interpreted*, may be used as a base for decision.

In all countries, and as much, if not more, in the so-called developed countries than in those which appear less developed, a vegetation map represents, without any doubt, the most efficacious and least onerous synthetic document to produce, in order to establish a reasonable and rational programme for the preparation and development of a territory.

Any attempt at economic planning in fact implies two distinct stages:

A stage of *preparation*, involving an outline plan of long-term prospects, laying down by means of an *inventory*, the *potentialities* of a territory within the limits of a *revolution*, that is to say a period of time at the end of which a fresh inventory may lead to an assessment;

A stage of *development*, which must be subordinated to the preceding stage, and which is designed to develop one or more potentialities within the limits of the equipment provided.

Development is a means of preparation, and only the latter involves the responsibility of its promoters with regard to biological equilibrium over a period of time. Botanical cartography, when properly conducted and correctly utilized, can provide very cogent, and indeed compelling, factors of decision-making in both these sectors.

For a fruitful dialogue to take place between the phytocartographer and the economist, it is essential to perfect a common language.

An immense educational effort is required for this purpose: if it is generally admitted that a geological map can only be utilized after very exact processes of initiation, provided almost for the past century by all the universities of the world, it must *a fortiori* be conceded that requirements of the same kind apply in the case of vegetation maps, whether for their production, interpretation or utilization.

The Centre national de la recherche scientifique (National Centre for Scientific Research) has, for its part, two specialized institutes: the Service de la carte de la végétation (the Vegetation Map Department) at Toulouse, and the Centre d'études phytosociologiques et écologique (the Centre for Phytosociological and Ecological Studies) at Montpellier, which work in close co-operation with the organs of higher education, such as the Centre de biogéographie 3e cycle (Third Cycle Biogeographical Centre), the Service de cartographie et photogrammétrie de la Faculté des sciences de Toulouse (the Department of Cartography and Photogrammetry of the Faculty of Science of Toulouse), the Institut de la carte internationale du tapis végétal (Institute of the International Map of Vegetation Cover) of the University of Toulouse, or the Centre d'écologie 3e cycle de la Faculté des sciences de Montpellier (Ecological Centre, Third Cycle, of the Faculty of Science of Montpellier) and can contribute very largely to encouraging the expansion of a variety of research activities, the efficacity of which has been demonstrated, both in basic science and in its application to the economy.

AERIAL PHOTO INTERPRETATION FOR THE EVALUATION OF VEGETATION AND SOIL RESOURCES

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TERRITORIAL ATLASES—THE PRODUCTION PROBLEM FACING SURVEY DEPARTMENTS WITH LIMITED RESOURCES[1]

By A. G. Dalgleish, B. A.(Cantab.)

Introduction

The rapidity with which the 1st edition of the Kenya Atlas sold out and the flood of advance orders for the 2nd edition from Kenya and overseas, indicates that there is a very considerable demand for this type of publication. Nevertheless, the decision of a Government Survey Department to undertake the production of a territorial atlas is not one which can be lightly made.

Much of the work involved is fascinating and of excellent training value for cartographers, but it is also rather expensive and time consuming. In the notes which follow, I have attempted to outline the production problem, from the point of view of a government survey department with limited resources, and to describe briefly the methods adopted by the Survey of Kenya in our attempts to produce an acceptable atlas with the facilities available to us.

General planning

Although the Oxford dictionary defines an atlas merely as "a volume of maps", a modern atlas is not a hotch-potch of un-co-ordinated individual maps but a homogeneous collection, demonstrating throughout the results of skilful guidance and choice. The individual maps must be on a projection, and at a scale, suitable to the subject they illustrate. They must, as far as possible, be in conformity with other maps, and must express their purpose simply and clearly.

By careful selection and presentation of material, by judicious choosing of colours acknowledged to be suitable, and by maintaining a uniform standard throughout, it is possible to produce an atlas which gives pleasure and is artistically satisfying.

This statement which is freely adapted from a report on a proposed atlas for Primary and Intermediate Schools in Kenya by the Kenya Education Department's Inspector of Geography, aptly sums up the aims of every conscientious atlas compiler; nevertheless, in the initial planning stages, attention always turns to "how have other people done it?" and "how successful have they been?".

Before embarking on detailed planning therefore, it is well worth while to examine critically as many examples as possible of existing published atlases. Such an appraisal was made by the Survey of Kenya in 1956 and thereafter, a committee of senior departmental officers was set up to make recommendations on general policy, for the production of an Atlas of Kenya.

The committee's terms of reference were to draw up detailed proposals on contents, map scales, format, style, quality of paper, type of binding, selling price, etc., in such a manner that maximum use could be made of source material and reproduction facilities already existing within the Department. It was generally agreed that if the project were ever to reach fruition, expenditure of public funds must be kept to a minimum and costs must be largely recoverable from sales of 2-3,000 copies of the Atlas.

After due consideration, the committee reached the following conclusions:

1. *Contents*

The contents decided upon were:

1. Kenya in relation to Africa.
2. Kenya, physical and general.
3. Provincial maps (set of six maps).
4. Kenya administrative divisions.
5. Kenya meteorology (set of three maps).
6. Drainage and water board areas.
7. Geology.
8. Soil.
9. Vegetation.
10. Agriculture.
11. Forests.
12. Malaria incidence.
13. Tsetse fly infestation.
14. Tribal and ethnographic.
15. Population.
16. Land divisions.
17. Game reserves.
18. Mineral deposits.
19. Communications.
20. Medical facilities.
21. Postal facilities.
22. Educational facilities.
23. Police organization.
24. Water supplies.
25. Location of industry and power.
26. Exploration.
27. Nairobi.
28. Mombasa.
29. Smaller towns.
30. Administrative divisions of old E.A. Protectorate.
31. Historical maps (set of five maps).
32. Gazetteer.

In all, 44 maps and 10 pages of text were planned.

2. *Map scales and format*

A sheet size of 19″ × 18″ was chosen to allow the use of a $\frac{1}{3}$ m. base map to illustrate, with reasonable clarity, the various biographical and human geographical distributions. This size also proved most convenient in allowing the use of a standard scale of 1 m. for the Provincial maps.

In deciding on a suitable sheet size, consideration must also be given to the convenience of users of the *Atlas*. Although it is felt that the *Atlas of Kenya*, in common

[1] The original text of this paper, submitted by Kenya, appeared as document E/CN.14/CART/32.

with several other territorial atlases, is far too large for convenient handling and storage, the difficulties which would be introduced by the use of a divided format to reduce page size tend to preclude this expedient.

All of the proposed contents were accepted for inclusion in the 1st edition of the *Atlas*, and with a few additions have been repeated in the 2nd edition.

3. *Style*

A "conventional" atlas style of cartography employing layer tints was chosen, it being argued that it is better to do the conventional really well than to experiment with more advanced techniques which might not prove entirely successful. However, as a concession to newer cartographic techniques, it was decided to include one relief map of Africa on which the relief was illustrated by hill shading produced photographically from a plastic model.

4. *Quality of paper*

In view of the number of colour impressions and the necessity to back up some sheets, it was decided that the paper used should be 150 G.S.M. offset cartridge.

5. *Type of binding*

As the Survey of Kenya has no machine binding facilities, a loose-leaf type of binding was chosen. This it was hoped would serve a dual purpose, in that it would make possible the collation and binding of the atlases within the Department, and would also allow for the addition of further maps which could be published as loose sheets from time to time. In any event, the secondary purpose has not been realized.

6. *Selling price*

To enable the capital outlay in time and materials to be recovered from a relatively short run of approximately 2,000 copies, it was recommended that if the distribution of complimentary copies was severely restricted, the estimated costs could be recovered at a selling price of sh. 50/- per bound copy, and sh. 2/- for individual map sheets. These recommendations were accepted by the Ministry of Education, Labour and Lands. In general, the estimates have proved satisfactory from a costing point of view but, with no profit margin and our lack of experience of the book trade, we soon received complaints from booksellers that the atlases were not economical for them to handle. Accordingly, the retail price of the 2nd edition has been increased to sh. 60/- to allow for the normal discount on wholesale orders, without loss of revenue.

7. *Compilation*

Having decided to proceed with the project, a senior cartographer was appointed to collect and edit the information required for the maps, and to supervise the drawing. The provincial and physical maps presented no particular problem, as suitable material already existed, and required only re-compilation into atlas sheets. For the various distribution maps, however, it was necessary to enlist the aid of specialists in other government departments and organizations, to obtain or verify information on the subjects to be illustrated. This stage can be most frustrating for the atlas compiler, particularly when working on 1st editions. Whilst we found an almost universal willingness to co-operate, not everyone had information immediately available in suitable form for direct compilation. Several specialist had very decided views on how their information should be presented. Where these did not accord with the views of the editor, some compromise was necessary. The views of individual contributors must always be considered, but it is important to the success of the whole to prevent such individuals from usurping the Editor's functions entirely. Satisfactory progress was made through the preparation of rough mock-up Atlas sheets, with coloured crayons on prints of the standard base map, which for the 3/m. sheets was drawn at $\frac{1}{2}$ m. scale. These drafts were amended as necessary until agreement was reached.

For the 2nd edition of our *Atlas*, the procedure was much simplified, since the contributors knew the required layout and could use 1st edition sheets as their basis of revision. Moreover, considerable benefit was derived from some of the detailed criticisms and reviews of the first edition plates. Considering the difficulties encountered by editors in collecting material for atlas maps, it is always surprising how much useful information is gratuitously supplied immediately when the maps are published.

When producing an atlas on a show-string budget and in addition to the normal production of a Survey Department, maps must be completed and printed over a considerable period of time. It is inevitable, therefore, that on publication of the complete atlas, some maps will be more up to date than others. It is as well to advise contributors of this fact in advance. By giving firm "cut-off" dates for each map after which no further amendments can be contemplated, it is possible to simplify the fair drawing and printing through the elimination of last minute corrections. In spite of well laid plans, however, last minute amendments will still arrive and it is often very difficult to decide whether they are of sufficient importance to warrant a set-back in production.

8. *Fair drawing*

Fair drawing techniques tend first to be decided by the availability of materials and the training background of the draughtsmen, but can be modified later with experience. We started initially with two draughtsmen using the conventional technique of drawing in ink on Astrafoil to produce the line plates at a drawing scale of $\frac{1}{2}$ m. for the $\frac{1}{3}$ m. base maps, and 1:750,000 for the 1/m. provincial maps. The number of draughtsmen was increased to five as the work progressed.

Overlay material for use on the base maps, and the colour masks for layer tints were produced directly at publication scale, using the same technique. We have now had more experience in the use of peel-coat film for colour masking, and will no doubt change over to this method on future projects.

The type used, with a few exceptions, was Gills Sans in various point sizes, set up and printed on "clarafoil" on a Littlejohn press, then waxed prior to issue to the draughtsmen. Here again the recent acquisition of a

Hohlux photo-typesetting machine has increased the flexibility of map design by increasing the range of available type faces and point sizes. For the 1st edition the letterpress required for the pages of text had to be contracted out to the Government Printer, who supplied art-pulls for subsequent reproduction by offset lithography. Letterpress for the 2nd edition was set up within the Department.

9. *Proving*

All the completed maps were proved photo-mechanically on opaque astrafoil. As this process is rapid, effective and relatively cheap, it is to be recommended for all maps except those in which final colours are obtained by tint combinations. For these, for example geological and soil maps, no substitute was found for machine proving.

10. *Printing*

All our printing was carried out by offset lithography on Crabtree rotary presses, which are capable of maintaining fine register. In the 2nd edition the quality of the printing has been considerably improved through the use of more refined ready-mixed plate coatings than were available to us for printing the first edition.

11. *Gazetteer*

The usefulness of an atlas is much enhanced by the inclusion of a comprehensive gazetteer. The compilation of a gazetteer is, however, a tedious business which can only be really simplified if one has access to a suitable card sorting machine. As this is usually out of the question, some other means must be devised. Our solution was adapted from the card-sorting technique and proceeded as follows.

First, to obviate the need for constant repetition of generics such as town, river, mountain, etc., the gazetteer was divided into sections under these various categories.

Next, a quantity of paper slips were cut to equal size (approx. $7'' \times 1\frac{1}{2}''$). Then, working through the topographical section of the *Atlas*, map by map, every name was transferred to a separate slip of paper, quoting also the map number and map square reference, thus:

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keeping the various categories in separate bundles.

Once all names had been transferred, each bundle was sorted alphabetically, initially under the first letter of the name, and subsequently into proper alphabetical sequence.

The information was at this stage compiled into manuscript lists (in block capitals) and set up in type. Proofs made from the type pulls were re-compared with the maps. All that was then necessary was the preparation of a "stick-up" of the columns of letterpress to suit the required layout ready for photography and plate-making.

12. *Collation and assembly*

The collation and assembly of atlases into the type of loose-leaf binder chosen for the *Atlas of Kenya* presents no great problem to the average Survey Department, provided that at the printing stage care is taken to see that all printing plates are laid to a standard position and machine "lays" are adjusted to ensure that each map is printed in the same relative position on the paper. If these conditions are met, the contents of each assembled atlas can be trimmed as a book and drilled as a unit.

The only requirements are sufficient space to lay out the stacks of printed maps in proper sequence in such a manner that each collator can collate one complete atlas at each tour of the room. We have found that six collators, one guillotine operator, one paper driller and two binders can assemble atlases at the rate of 60-70 per hour.

Considerable trouble was experienced in assembling the 1st edition *Atlas* owing to faulty manufacture of many of the binders. Although the manufacturers eventually rectified the matter, we learnt a valuable lesson that the acceptance of the lowest tender is not always economical in the long run.

CONCLUSION

In conclusion, I should like to emphasize that in the foregoing factual account of the production of the *Atlas of Kenya*, no claim is intended that our solutions of the various production problems are the best possible. My object is merely to record for general interest how a government survey department concerned with and equipped solely for the production of title surveys and basic mapping, can produce a territorial Atlas largely from within its own resources.

MEMORANDUM SUBMITTED BY THE INSTITUT FRANÇAIS DE L'AFRIQUE NOIRE (FRENCH INSTITUTE FOR BLACK AFRICA)—DAKAR

(In connexion with the International Atlas of West Africa)[1]

The plan to produce an International Atlas of West Africa, proposed by Professor Th. Monod, Director of the French Institute for Black Africa (IFAN), was adopted at the first session of CIAO—*Carte internationale de l'Afrique occidentale* (*International Atlas of West Africa*)—held in Dakar in 1945 and attended by most of the experts on West Africa.

The establishment of a geographic unit in the Institute made it possible to submit a precise plan to the second session of CIAO, proposing the preparation of sixty

[1] The original text of this paper, submitted by France, under the "Note présentée par l'Institut français de l'Afrique noire de Dakar, à propos de l'Atlas international de l'Ouest africain", appeared in French as document E/CN.14/CART/90.

plates and suggesting methods of work. The general lines of the plan were improved in the light of the information acquired and working groups were set up at the two meetings held at Dakar in 1955 and 1956. Because of limited funds, it was not possible to do more than collect the necessary documents and draw up a certain number of rough sheets.

Moreover, political changes afforded an opportunity to review the organization of the work.

On 25 November 1960 the IFAN Geographic Unit issued a 60-page booklet containing a balanced plan for the mapping in 48 plates of the various sections of the West African economy. This plan, which had the benefit of the extremely valuable comments and suggestions made by several English-speaking and French-speaking experts, served as a basis for discussion at the Conference on the International Atlas of West Africa which was held at Ibadan University from 16 to 21 March 1963 under the auspices of the Institute of African Studies.

The plan of the Atlas shows a continuing progression from map to map, in such a manner that each map has been prepared by its predecessor and in turn constitutes a preparation for its successor.

West Africa is first of all considered from an outside angle. Two planispheres locate its world position from the physical angle: first the climates, then the land and submarine relief, continuing in the second sheet to the coast-line, which are the special coastal features.

The first maps of West Africa are relief maps which will be submitted in 4 sheets on the scale 1:2,500,000. There are few precedents for this. We formerly used the map of the National Geographic Institute in Paris but now the *Times Atlas* map on the scale 1:5,000,000 is in current use.

There are also the International Civil Aviation Organization's sheets showing altitudes at successive levels of 300 metres or 1,000 feet. But there is no comprehensive document covering West Africa as a whole that is sufficiently precise, on a scale still permitting the inclusion of details as well as global view, while taking account of up to date information, which is in many ways highly advanced.

It is advisable to stress the difficulties encountered in arriving at such a synthesis. To begin with, there is the question of scales. The normal procedure would be to start out with maps on the scale 1:1,000,000 or 1:500,000; but there is only a limited number of these, like maps of Nigeria (which are old) and these of the Geographic Service in Dakar. None of these corresponds to the system of contours adopted. Higher scales had therefore to be used, including the 1:200,000, the 1:100,000 and, in some instances, the 1:50,000, as in the case of Portuguese Guinea, the Republic of Guinea, and part of the Ivory Coast and Dahomey, pending the contemplated generalizations.

This means that the main body of maps to be reduced and assembled is very considerable; but the difficulties involved are nothing in comparison with that of selecting the contour lines. Arithmetical progression was abandoned because the lower altitudes could not be distinguished without too great a diminution of the equidistance between contours. It was therefore decided to try the geometric scale, which is used for most hypsometric maps featuring 200, 500 or 1,000 metres; but it soon became evident that the greater part of the centre of West Africa would thus lack differentiation, and so the intermediate values of 50—100—350—750—1,500 metres were adopted. Unfortunately the intermediate values are not always given, nor do they correspond to the current deviations in feet. It was therefore necessary to interpolate freely at the risk of exercising the imagination or lessening the fidelity of representation in the case of certain maps, particularly those dealing with the zones showing less relief. This was the only solution making it possible to produce a series of extremely dissimilar maps at all comparable, and experience has shown the result to be fairly satisfactory.

Nevertheless, the main difficulty still resides in the vast areas for which there are no maps by means of which the relief can be plotted by contours or coloured areas. We are faced with a dilemma. Should they be left blank, as on a detail map based on aerial photographs obscured by clouds? That would be regrettable because partial information is nevertheless available, and also because the whole picture would suffer. The question arises in connexion with Liberia, a few areas in Ghana and Dahomey and, lastly, the Sahelian zone north of the 16th or 17th parallel.

Nevertheless, this immense area has been covered by vertical photographs on the scale 1:50,000, giving rise only to maps which have not been completed on the terrain. In this case, it seems advisable not to overlook this tremendous documentary source and to emphasize such elevations on our map by a discontinuous delineation of the major contour levels as shown on the photographs. This inevitably means discarding the map for the sketch; but the aim, which is to point out the facts as they are known today, will be attained, yet this will not prevent the notice from clearly showing the value of the source material.

Comparatively speaking, it would seem far less difficult to establish the hierarchy of the hydrographic network, or to select the geographical names and expressions. There is still, however, a great deal to be done in connexion with the form—for instance, the transcription method—and the substance, by standardizing names after a critical study of the terms proposed by the various contributors.

It should be added that the various coloured areas are in the traditional shades of green, yellow and reddish-brown, which are still the most evocative.

Then we come to hydrography, insufficiently distinguished on the relief maps, in the same way as fluvial systems cannot be shown; and then to explanatory maps: geophysical phenomena, structure and tectonics. As for geology, this is a familiar subject nowadays and there is no difficulty in producing a very complete map on the scale 1:5,000,000; the difficulty lies in collating the elements of the work done by geologists according to the English and French traditions, but it is an excellent opportunity to try. That is how the pedologists arrived at a very satisfactory picture of their task as a whole,

and the work they did under the auspices of the CSA (Scientific Council for Africa) will be directly incorporated in the *Atlas*, with the permission of the publisher. As regards morphology, a further aspect of physical phenomena, a heavy amount of team work will have to be done, but the results will be all the more valuable because they will be up to date. The climate reacts on the earth's crust and its role is only too obvious in explaining human settlements; it is also fairly widely studied. Many plates will therefore be devoted to describing its multiple aspects, annual, but also monthly elements, by examining successively rainfall, temperature, hygrometry and winds.

Reliefs, soils, climates explain phytogeography and zoogeography and, by degrees, we come to the description of the human phenomenon—normal man, pathological man, historical antecedents and population densities. These last maps should be the counterpart of relief maps and consequently occupy 4 complete sheets which can be joined together. The quantitative aspect has to be stressed by showing the unevenness of human concentration, rural and urban populations, spaces given over to nomadism, suitable or highly unsuitable areas. This provides the reasons for, and a partial explanation of, all subsequent maps: subjective aspect, the various human groups, resumed in the related maps of linguistic, cultural and religious areas.

The later maps are principally of an economic and social nature, soil utilization together with the international map of the World Atlas of Agriculture, and should, as far as possible, show extent to which the soils are utilised, those soils which cannot be used, those which are extensively used and the sectors of intensive cultivation; it is seen how reference to the pedological map will be extremely advantageous and how both prepare the way for the map of agricultural production. Special maps will show aspects of traditional social life with types of soil, village and dwelling.

The last series of maps will deal with modern Africa through its industries, communication networks, trade and economy; the administrative district, educational and public health installations, telecommunications, urbanization and types of towns will be shown: all maps which do not exist on the level of Africa but which nevertheless are full of interest and easy to compile with the assistance of the various administrative services of States.

The last sheet will be a planisphere showing the situation of West Africa in the world, from the point of view of economics and intercontinental liaisons.

There will be a total of 48 plates; but there will be two series of 4 on the scale 1:2,500,000 (relief and population), 16 on the scale 1:5,000,000 which may be considered as the base scale, 38 on the scale 1:10,000,000, 16 on the scale 1:15,000,000, and 75 on the scale 1:20,000,000 without counting the inset maps on various scales for types of town, village or soil.

The explanatory notes intended to indicate sources and facilitate reading of the maps will also include inset maps, diagrams and statistics. They will not be inserted in the *Atlas* but will appear in the form of small, extremely flexible brochures.

The *Atlas* itself will appear as a 52 × 38 cm. book, which will ensure that it is easily handled. It will have a loose binding to make it easy to consult the maps and bring them up to date. The opened page thus offers a useable surface of 70 × 46 cm., which is quite sufficient to cover the structure and general situation of West Africa.

The great advantage of the *Atlas* obviously results from the scale on which the structure and difficulties are shown. Between world Atlases which, because of the immensity of African regions cannot easily display their physiognomy, and national Atlases, of which very interesting ones, such as that of Sierra Leone, do exist but which aim especially at educating the nationals of the countries they depict, between the two types, there is undeniably room for a medium-scale map showing more particularly interactions across a portion of continent with numerous complementary elements.

Political frontiers often mask a real physical or human continuity. There are no natural breaks in the Sudanese area from Dakar to Chad any more than there are distinct boundaries between that area and the Sahel or the Forest. Production and means of existence are almost the same over immense stretches of land. A great river like the Niger may be a powerful unifying factor. The populations circulate freely and migrations have become a question of prime importance in modern Africa. The States themselves feel the imperative need to join together well beyond their respective frontiers.

In many respects, therefore, West Africa appears as a remarkable regional framework. Although precise boundaries for it cannot be fixed, it will be admitted, that, roughly, the Chad meridian with the mountain barrier of Cameroon forms such a boundary with Central Africa while the Tropic of Cancer is another boundary with the North. There, human densities and vegetation cease almost completely and definite knowledge about the physical environment (relief, geology, meteorology) declines accordingly. The political frontiers in those areas are very undecided although drawn in wide sweeps and, although the maps of States must necessarily emphasize them, in the case of purely scientific maps the framework indicated will amply suffice to explain this region which is defined particularly by its content.

Even in its preparatory stage the *Atlas* is of scientific interest. As a synthesis, it requires discernment in collection, choice of documents, research into the causal link between the various phenomena resulting from a common localization or distribution.

There is no need to insist on this point which justifies the work of synthesis, with the peculiarity that the person who deals with cartographic representation has the advantage of frequently correcting his judgement and so obtaining a clearer view of matters. The aberrations found in the works of the first scientific authors and, even earlier, in those of the Arab writers are astonishing; in many cases it must be noted that they were due to a very pardonable lack of knowledge of geography.

At the publication stage the *Atlas* will become a point of contact between the disciplines themselves. Thus, doctors who wish to control an endemic disease are at

the outset confronted with matters of geography: first, what is the area of this disease—and it is up to them to determine it—and how many persons in that area is it liable to affect? That information will be supplied by a map of population distribution. What factors are involved? It is at this stage that the doctor will consult the synoptic climatic maps, without profusion of detail—at least in his first approach which will be an act of pure reflection and not a statistical hazard. He will also willingly consult the economic and administrative maps which will enlighten him concerning the social situation. The ease with which the *Atlas* can be used will cause him to return often to certain maps which will become one of the focal points of his meditations.

It is probable, from a theoretical point of view, that the *Atlas* will provide everybody with a means of improving his knowledge of those subjects in which he has not specialized by making it possible for him, through untrammelled reflection, to widen his field of knowledge without obliging him to give himself up to studying an abundant but also very fragmentary literature. The *Atlas* thus provides the bridge between the human and natural sciences which, for purely pedagogical reasons, are often separated, although human and natural scientists should constantly draw inspiration from their complementary knowledge; the humanists, to maintain the sense of the concrete, the sense of nature which imposes its restraints but is always ready to serve those who deliberately seek its assistance; the naturalists (in the widest sense), to remind them that the ultimate aim of their work should be to improve the human condition.

Is it not comforting to think that if this team work meets the double requirement of scientific exactitude and humility, it may become an essential tool for all Governments responsible for deciding the way in which the States of West Africa are to develop?

The *Atlas* is already in process of completion. The Institut français de l'Afrique noire in Dakar has patiently ensured the preparation of three large series of maps (relief, climate, population) which alone represent one quarter of the work. After having collected the base documents, some of which were bought in the trade but many of which belonged to public services or research workers who have always readily met requests, the rough maps, after having been compiled and arranged, have largely been completed and handed successively to specialists for the critical examination which must precede the final drawing. The collaboration of the English-speaking African universities, particularly that of Ibadan, is in this connexion full of promise and the scientists of the various branches are already undertaking the preparatory work for certain maps (geology, pedology, phytogeography, zoogeography, pathology, and the like).

Thus, a first series of plates will soon be published, in the hope that the requests for grants for publication addressed to the international organizations will meet with a favourable response.

PROGRESS REPORT ON COMPILATION OF THE ATLAS OF MOROCCO[1]

In 1954-1955 the Comité de géographie du Maroc (Moroccan Geographical Committee) was able to bring out the first instalment of the *Atlas of Morocco.*

The technical production of the *Atlas of Morocco* was entrusted to the Laboratoire de géographie physique de l'Institut scientifique du Maroc (Physical Geography Laboratory of the Scientific Institute of Morocco). The laboratory uses for its work, with the aid of specialists, whether geographers or not, a series of documents supplied by the public services and by the scientific research institutes.

According to the general plan of the *Atlas of Morocco*, the plates should be divided into 54 chapters grouped into 11 sections. If the size of subject treated makes it necessary, each of the chapters may be subdivided.

The size of each of the plates of the *Atlas of Morocco* is such that according to the matter under treatment one-quarter of Morocco may be set out on the scale 1:1,000,000, or the whole of Morocco on the scale 1:2,000,000 or again four maps of Morocco on the scale 1:4,000,000.

The presentation of the 1:1,000,000 sheets has been designed in such a way as to enable them to be assembled into a single map. The maps are in colour; explanatory notes drafted by specialists accompany each plate, making it a complete work of reference.

Between 1954, when the first plate appeared, and 1962, 12 plates and 11 notes appeared:

Railways: 2 plates and 2 notes (1954-1955)

One plate, consisting of one map on the scale 1:2,000,000 and 3 inset maps, contains a study of the Moroccan railway network, its installations, organization and passenger traffic on the various lines.

Another plate represents freight traffic on the Moroccan railway.

Animal breeding: 3 plates and 3 notes (1954-1955)

One plate entitled "animal breeding: sheep and Goats" consists of one map of sheep and goats on the scale 1:2,000,000, one inset map of different sheep breeds and a diagram of annual variations in sheep and goat livestock.

Another plate deals with cattle, pigs, camels, horses: it consists of 4 maps on the scale 1:4,000,000.

A final plate, devoted to cattle markets and the situation of veterinary services, consists of one map on the scale 1:2,000,000 of cattle markets and 3 inset maps.

Geography of diseases: 1 plate and 1 note (1956)

The plate showing the geography of human diseases

[1] The original text of this paper, submitted by Morocco, under the title "L'état des travaux de l'atlas du Maroc", appeared in French as document E/CN.14/CART/92.

comprises 4 charts on the scale 1:4,000,000: malaria, tuberculosis, trachoma and bilharziasis.

European farming establishments: 1 plate and 1 note (1958)

The plate is for the purpose of studying European farming establishments in Morocco as regards the areas under cultivation and the type of establishment. It comprises:

One main chart consisting of 3 sheets, showing the European rural properties on the scale 1:1,000,000.

Three inset maps attached to the 3 sheets showing the same distribution on the scale 1:1,500,000, but in terms of the European cultivation areas.

Four maps on the scale 1:3,000,000 showing the distribution of the main European agricultural products.

Annual rainfall: 1 plate and 1 survey note (1958)

The plate showing Morocco's annual rainfall comprises:

One chart: average annual rainfall on the scale 1:2,000,000

Three inset maps: number of rainy days on the scale 1:5,000,000
number of dry months on the scale 1:8,000,000
rainfall measurement network on the scale 1:10,000,000.

Forests: 1 plate and 1 note (1957-1958)

The plate shows the geographical distribution of forests and the main features of the forest situation throughout the country. It comprises:

One main map of forests in 4 sheets on the scale 1:1,000,000

One inset map: forest situation on the scale 1:2,000,000.

Distribution of salt waters in Morocco: 1 plate and 1 note (1960)

The plate showing the distribution of salt waters in Morocco comprises:

One main chart: distribution of salt waters on the scale 1:2,000,000

Two inset maps: surface salt water courses on the scale 1:4,000,000
deep salt or selenitic waters on the scale 1:6,000,000.

Mining industry: 1 plate and one note (1961)

This plate covers the mining industry of Morocco. It comprises:

One main map on the scale 1:2,000,000, entitled Mining Industry, the purpose of which is to list the mining operations of an average year (1959).

Three inset maps: potential resources on the scale 1:4,000,000
mining population and migratory movements on the scale 1:5,000,000
Oulad-abdoun phosphates bed on the scale 1:1,000,000.

Metallogenic chart: 1 plate (1962)

This plate comprises 3 sheets, brought up to date in 1954, and published with a few changes in 1962. The graphic synthesis and preparation of the documents are the work of the Geology Division of the Directorate of Mines and Geology, Rabat.

One sheet on the scale 1:2,000,000 shows the deposits linked with eruptive rocks;

One sheet on the scale 1:2,000,000 shows the secondary hydrothermal deposits;

One terminal sheet on the scale 1:2,000,000 shows the sedimentary deposits.

A new series of plates will be issued in the course of 1963.

Distribution of population (1960)

This plate will comprise:

One map on the scale 1:2,000,000 showing the towns and densities of rural population, on the basis of the smallest administrative areas, the rural communes.

Two inset maps on the scale 1:5,000,000 will show:
The distribution of foreign population.
The distribution of Moroccan Israelite population.

Distribution of population (1960)

This plate will comprise a chart on the scale 1:2,000,000 of the distribution of the population, each dot representing 500 inhabitants.

Administrative organization

This plate will consist of 1 chart on the scale 1:2,000,000 showing the administrative organization of Morocco. It will indicate the boundaries of all the administrative districts, including the rural communes.

Bioclimatic stages

This plate will comprise 1 chart on the scale 1:2,000,000 showing the bioclimatic stages in Morocco, plotted in accordance with the Emberger quotient, together with 2 inset maps.

Use of water

This plate will comprise 1 chart on the scale 1:2,000,000 on the use of water in Morocco, showing the traditional and modern irrigation sectors. An inset map will indicate the country's water resources.

Hypsometric chart

This plate will comprise 1 chart on the scale 1:2,000,000.

PRESENTATION OF THE GEOPHYSICAL MAPS COMPILED BY ORSTOM[1]

Office de la recherche scientifique et technique outre-mer

Geophysical maps fulfil a specific purpose which it is important to define, in order to permit proper appreciation of the form in which those compiled by ORSTOM have been produced. Their purpose is neither representation of the terrain (topography), nor the synthesis of this or that phenomenon or type of activity directly connected therewith (topical maps), but representation of the measured values of the permanent geophysical fields—the magnetic field and the gravimetric field. (This is in contrast to meteorology, which is the study of values of varying magnitude, and in terms of cartography, the study either of average values or of instantaneous situations). As the local intensity of gravity is affected by relief, it has been necessary to specify, for purposes of cartographic representation, a characteristic magnitude, Bouguer's anomaly, which disregards the known and calculable effects of relief, height and latitude, and in short represents the residuum, after all the known causes of variation have been taken into account in analysis of the measurements.

The location of points of measurement could be shown by the network of geographical co-ordinates alone, but it is convenient to provide as a complement to this network a minimum of topographical indications, thus helping the reader to find his bearings quickly. These topographical indications must remain sufficiently discreet not to hinder the study of geophysical data; and this leads to elimination of a solution consisting in showing such data superimposed on a topographical map.

The essential data adduced by the maps are the values observed, subject to corrections, shown at the points where field stations are located. It should be emphasized that supplementary data on these stations (exact position, complete results of measurements) are preserved, and made available to users on request. Besides this, the curves of equal value are plotted, and enable the values at any point to be calculated by means of interpolation. Moreover, they provide a picture of the general appearance of the magnitudes measured, and thus serve as a basis for all interpretations, in relation also to the geological structure; but in any such interpretation; it is essential to draw a proper distinction between the areas where the plotting of curves of equal value is supported by an adequate number of measurements, and the areas where the measurements have been connected in a more approximate manner, in which case the positions of the stations must be indicated.

The whole range of maps on a 1:5,000,000 scale will be presented to show the elements of the magnetic field in West Africa. Of these elements, the declination is the most widely employed for determining directions by means of the compass (aviation, topography).

The gravimetric maps on a 1:1,000,000 scale of the Ivory Coast are presented as specimens for the numerous sheets, for which Orstom undertook surveying and publication, some of them in two successive issues, where the first issue was the result of still incomplete exploratory surveying. The density of stations which allows the precise plotting of curves of equal value on this scale leads, as may be seen from examination of the maps presented, to a definition of the field of gravity that is sufficiently precise to permit the study of numerous correlations with geology; and if the examination of a particular problem called for a larger-scale survey, its scope could be easily defined.

The isostatic map on a 1:5,000,000 scale of West Africa answers a rather different purpose. The isostatic anomaly, of which it shows the values, is not derived as directly from the measurements as in the Bouguer anomaly; it contains an element of hypothesis, and corresponds to what would be the imbalance for a certain conventional model of the structure of the earth's crust. Whereas Bouguer's anomaly is used to explain local geological structure, the isostatic anomaly has a far more regional significance, which justifies the choice of a smaller scale. Moreover, it is important to give prominence first of all to the positive (heavy) areas and negative (light) areas, and to the limits separating them, which may constitute areas of instability; these areas have been distinctively shown by the use of very contrasting shades of red and blue. The map presented is a second edition, and much more complete than the first edition (1960), owing to the incorpation of work carried out in the meantime.

[1] The original text of this paper, submitted by France, under the title "Présentation des cartes géophysiques de l'ORSTOM", appeared in French as document E/CN.14/CART/29.

AGENDA ITEM 15

Preparation and reproduction of maps and other questions related to map compilation, geographical names, etc.

GEOGRAPHICAL NAMES IN EMERGENT MULTILINGUAL COUNTRIES[1]

Prepared by J. Loxton, M.A., F.R.I.C.S.

A study of survey and mapping periodicals and conference proceedings reveals very little material on the subject of geographical names and suggests that cartographers take an unsufficient interest in this aspect of their work. Most of recent significant thought and investigation has been by experts in other fields, e.g. languages or anthropology. Of work published in the English language, the papers of Aurousseau, Berry and Burrill at the Fifth International Congress of Toponymy and Anthroponymy at Salamanca in 1955, and other works by the same authors, are particularly valuable to cartographers.

Cartographers have a special responsibility for geographical names because once a name appears on a map, it is, rightly or wrongly, accepted by a great many people as authoritative both for geographical position and for spelling. They should therefore take positive action to obtain authentic and accurate names for all features shown on their maps. Where there is any doubt, the guiding principle should be that the whole of any name on the map should be easily recognisable as the name of the same feature when spoken by a local (possibly illiterate) inhabitant. ("Whole name" here means including both the generic (if any) and specific terms). Special difficulties in reaching the best forms arise in multilingual countries.

The many problems of initial recording of names, when the first systematic topographical mapping of a formerly primitive country is executed, are probably well known. The problems vary from place to place but some of the commonest are: absence of a written native language, transliteration of local orthographies, variations of local pronunciation or dialect, lack of knowledge of the native language by the travellers or surveyors who record the names, errors introduced by third-language interpreters, alternative names (in different vernaculars) for the same geographical feature, wrong spellings established by long usage, etc.

A few examples from Kenya may illustrate these points:

Except for the coast region, Kenya was a blank on the world map until 1883 when Joseph Thomson was the first traveller to make sketch-maps of his route to Lake Victoria. As with the many who followed him in the next 15 or 20 years, his guides and interpreters came from the Coast and their native tongue was Swahili, a language of the Bantu group. The interpreters, not unnaturally, had some difficulty in rendering non-Bantu names, which the travellers then tried to record in English orthography on their maps. Thus a name like *Ol-oldian* (Maasai language) was recorded as *Londiani* (the final i being typical Bantu). Similarly *Ol-onongot* has become *Longonot*. Many such distorsions have become established spellings and are unlikely to be changed.

In some places the early travellers failed to record a native name for a feature and therefore gave it an imported name, e.g. Lake Rudolf, Aberdare Range, Thomson's Falls. The reasons for not recording a native name varied: some places were uninhabited and hence had no name, e.g. Mackinnon Road, Hoey's Bridge; while some had no dominant native name, e.g. Lake Rudolf is named quite differently by each of the tribes (Samburu, Turkana, Merille, Gabbra and others) who live around it. Such imported names have therefore persisted.

Some imported names given to previously unnamed areas, however, have been overtaken by the growth of a nearby place and eventually superseded. Thus Port Florence was absorbed into *Kisumu* and Fort Harrington into *Moyale* while today *Murang'a* has overtaken Fort Hall in local usage.

In many places the early surveyors recorded a specific native name for a feature but added an English designation, e.g. Odiero Hill. Such hybrids are gradually being rationalised by the substitution on the map of the appropriate vernacular designation: in this area the vernacular is *Luo* and the name in local usage is *Got Kodiero*.

Such simple rationalisation is not always possible. Consider, for example, the *Uasin Gishu Plateau*. This area was known to the nomadic Maasai (who called it *Ewuasin Ngishu*) but had no settled inhabitants before the arrival of immigrant farmers in 1908. There is no true vernacular in the district today; certainly it is not Maasai and thus there would be no merit in translating the generic "plateau" into that language. (It may be noted here that outside a few places on the coast, Swahili is not a vernacular in Kenya; in the Nilotic, Hamitic and

[1] The original text of this paper, submitted by Kenya, appears as document E/CN.14/CART/6.

Cushitic language areas particularly, it is as much a foreign language as is English.)

A somewhat similar problem arises in several areas where the "immigrant" language is other than English, e.g. in the North-Eastern Region of Kenya, a high proportion of place-names are of Boran origin but most of the present inhabitants are Somali. It is difficult to decide whether the correct rendering of a name in such an area is according to the way it is pronounced in the original language or the way it is pronounced by the present inhabitants.

Another class of bilingual hybrids which presents a difficult problem in rationalisation is that which the native specific name is, or includes, a generic term, e.g. *Naivasha*, which derives from the Maasai *Enaiposha* meaning lake. We have a *Naivasha* town (which is an established name) and a *Lake Naivasha*, in which the English generic "lake" is as redundant as the "desert" in Sahara Desert (Sahara = deserts, in Arabic). We must continue to use it, however, to distinguish in doubtful contexts the lake from the town.

Finally, there is in parts of Kenya a problem of transliteration. Both Maasai and Kikuyu have their own orthographies which are officially recognised but which differ from Swahili. The Survey of Kenya, as the executive of the Kenya Standing Committee on Geographical Names, has a government mandate to spell native names on maps in Swahili orthography (which is a simplified form of the English R.G.S.II system).

Kikuyu uses the same alphabet as Swahili except that the Kikuyu letter "c" equals the Swahili "ch". However, many of the letters have a different pronunciation, particularly the vowels, which may be modified by various diacritical marks.

Thus the Kikuyu pronunciation of the town name written Kikuyu as *Thika* would be in Swahili *Dheka*. However, the form *Thika* has become established and cannot be changed. The fact that Kikuyu and non-Kikuyu pronounce it differently has to be accepted. Following from this, it has been decided that all Kikuyu names will be spelt on the map as they are spelt in Kikuyu, only omitting the diacritical marks and rendering "c" as "ch".

No similar problem arises in Maasai areas, because the Maasai orthography is a recent innovation and nearly all place-name spellings are already established in Swahili orthography.

In general, cartographers are not qualified to solve all the problems involved in determining correct place names, nor to give decisions on spelling. Any country in which such problems arise clearly requires a national committee or board with both the ability to find the best answers and the authority to publish them. Such a body should include experts in cartography, phonetic and languages and should have regional sub-committees whose members must have intimate knowledge of both the local geography and the vernacular.

It is suggested that this Conference resolve to urge member governments to set up such national committees, wherever this has not yet been done.

References

The book "The Rendering of Geographical Names" (1957) by M. Aurousseau, former Secretary of the British P.C.G.N., contains over three hundred references.

"The Place-names of Ghana" by Dr. J. Berry (1958) is very relevant to the present discussion.

NOTE ON THE SYSTEM OF TRANSCRIBING AFRICAN TOPONYMS FOR FRENCH-SPEAKING AFRICAN STATES SOUTH OF THE SAHARA[1]

Institut Géographique National, Paris

In 1957, the Institut géographique national had worked out a system of transcription applicable to the African toponyms of French-speaking States south of the Sahara. This system, considered as being provisional, had to meet the two following imperative requirements:

(1) Standardization of place names by the use of a coherent graphic system, unencumbered by unnecessary letters and signs.

(2) Restoration of an acceptable pronunciation of these place names, permitting their correct identification by a French-speaking reader.

The establishment of a system of this nature, therefore, presupposed, in the first place, the adoption of *guiding principles*, and in the second place the choice of a series of *conventions of detail.*

It may perhaps be not without value to recall these principles rapidly:

(*a*) Use of the Latin alphabet, as the base alphabet;

(*b*) All the letters must be pronounced; for practical reasons, however, which will appear later on, a restricted number of exceptions is admitted,

(*c*) Bi-univocal correspondence between the phoneme and its graphic representation.

As regards the conventions of detail, it has appeared preferable to avoid the use of diacritical signs, which are little known in French—and which are, furthermore, liable to disappear when copied in the absence of appropriate keyboards (typewriters, type-setting machines, etc.) —and to have recourse instead to digraphs. Certain of these digraphs kept their French phonetic values whilst

[1] The original text of this paper, submitted by France, under the title "Note sur le système de transcription des toponymes africains pour les États francophones au sud du sahara", appeared in French as document E/CN.14/CART/9.

others, on the contrary, represented by convention[2] particular sounds in the African languages in question. In both cases, in order to differentiate between them, these digraphs could be underlined.

A "phonetic convention", illustrating in summary form the body of these rules—principles and conventions of detail—appeared in the margin of maps issued by the IGN and its ancillary organs, and allowed a reader thus apprised to adopt a pronunciation which, if not perfect, was at least adequate for proper use of the map.

Since 1957, the French-speaking African States have all obtained their independence. In agreement with their Governments, and in most cases in execution of Technical Assistance agreements, the IGN and its ancillary organs have nevertheless been able to continue their cartographic mission. They have, thus gathered a considerable quantity of toponyms, and the work carried out has been enormous. The examination of the documentation assembled, and the review of conditions in which this work was carried out, have, however, brought to light, certain imperfections which are attributable less, perhaps, to the system of transcription itself than to its application. In the absence of a thorough knowledge of the multiplicity of the local dialects, often prevented by other overriding technical factors from carrying out an investigation that might throw more light on the matter and obliged to accept time-limits for completion of the work that left no margin, our topographers have been unable to avoid making some mistakes. So the Institut géographique national associates itself fully with the first recommendation made by the Group of Experts on geographical names (E/3441 of 7 February 1961), for the establishment of national services for geographical names.

In order to bring about bilateral agreements with these national services, and in order to take into consideration the experience acquired in the course of the last few years, the IGN considered that it would be appropriate to apply to the provisional system of 1957 certain improvements designed to facilitate its application, whilst allowing as faithful a reproduction as possible of the particularly rich range of African sounds.

The principles accepted in 1957 have been preserved, but in order not to increase excessively either the number of conventional digraphs or the number of diacritical signs, the IGN has had to conceive its new system of transcription more from the phonological than from the phonetic standpoint. The part reserved for phonetics still remains very important, but many shades of pronunciation will not be translated into writing if they are liable to involve any confusion about the meaning of the words used. With this new conception, after the necessary transitional period, it will be possible to simplify and improve perceptibly the first graphic systems adopted. It is certain that in the case of languages which have already been the subject of serious study, upon which reliance may properly be placed, the transitional period envisaged will be extremely brief. In the case of other languages, a delay of several years should allow the desired standardization to be carried out more completely.

As regards the convention of detail, an adaptation and standardization of the rules of spelling in French have been undertaken. Special groups of letters (digraphs) have been introduced in order to evoke sounds which do not exist in French; it has, however, been made a strict rule that names thus transcribed can be read by persons knowing French, by giving a sound that is as close as possible to the sound sought for.

Thus, the consonants: "b", "d", "f", "h", "j", "k", "l", "m", "p", "r", "t", "v", "z", are able to reproduce very accurately the African sounds; in contrast to this, reservations are necessary in the use of: "g", "n", "s".

There is no objection to the use of the letters: "a", "é", "è", "i", "o", "u", and the digraphs: "eu", "ou", with the same phonetic values as they have in French; but the transcription of the nasal vowels calls for some additional precautions.

Here then, very briefly described, is the system of cartographic notations which the IGN proposes to submit to the French-speaking African States for their acceptance. It uses the resources of the French language to the maximum, but at the same time permits the transcription of sounds peculiar to the African languages, thanks to simple conventions accessible to a very wide public.

It goes without saying that this system could be made subject to any modifications desired by the Governments concerned in order to take local pecularities into account. Bilateral agreements will be concluded accordingly with these Governments; in that manner, respect for the accepted rules will be guaranteed, and it will be possible to bring about a progressive standardization of the geographical names of each State.

In order to ensure the attainment of this result, however, close co-operation will be necessary between the specialists responsible for collecting geographical names and the competent national commissions, so that rigorous supervision can be exercised and the risks or error reduced to a minimum. It can only be hoped that these aims will soon be realized.

[2] This does not mean "arbitrarily", as reasons of a logical, historical or practical nature necessarily exercise their influence in directing choice to the most satisfactory correspondence.

TOPONYMY IN MADAGASCAR[1]

The chief characteristics of Malagasy toponymy may be defined as follows:

1. A relative simplicity, due to its eminently descriptive character, closely connected to physical geography and topography, and to the small number of names of foreign origin (Arabic or European). On the other hand, over most of the territory, the low population density and the instability resulting from local migrations cause a certain toponymic poverty and instability producing repetition or confusion.

[1] The original text of this paper, submitted by the Malagasy Republic, under the title "La toponymie à Madagascar", appeared in French as document E/CN.14/CART/35.

2. A transcription in a handwriting practically unchanged for more than a century, in Latin characters and in simple and phonetically univocal spelling, the language proper being derived from the Malayo-Polynesian family, lending itself to compound words and presenting a fundamental unity beneath the local variations of the different dialects.

3. The fairly considerable and rapid extension of a base cartography at an average scale (1:100,000) fixing and facilitating the localization of toponyms. This results in a progressive and systematic inventory, compiled to a large extent by the staff of the Geographic Service. All this has largely contributed to its official acceptance and dissemination among the public.

4. The standardization of geographical names has, therefore, been simplified, and in its general outline, suitable solutions have been found. The establishment of a National Toponymy Committee, the plan of which is being drawn up, will make possible its appropriate dissemination and contribute to its becoming official.

The Malagasy language, which belongs to the Malayo-Polynesian family of languages, is an agglutinative language, the words of which are formed by successive adjunctions from a root or simple word, with frequent modification of consonants or suppression of unaccentuated last syllables of component words, in liaison within the complex single word. This sometimes makes the task of decomposing compound words a delicate one and may lead to errors in transcription or translation; after some practice, however, the rules of these compounds, which are invariable, are easily remembered.

The name Amboropotsy, for example (the place of white birds or ox-peckers) must be decomposed into: "An–Voro (Na)–Fotsy".

In fact, the various local dialects are, under apparent differences, closely related[2] and the grammar and syntax are practically the same. In the main, the variations, with respect to geographical names, bear on:

Certain roots, giving distinctly different names to the same object according to the regions;

The tendency in some coastal dialects for final syllables to disappear (e.g. the Merina word lakana—canoe—becomes laka in Sakalava), or for their endings to be modified (e.g. "Ka" or "tra" tend to become "ki" or "tri", "Ko" or "tro");

The changing of certain letters (for example d into l).

These variations have sometimes led to errors in interpretation on the part of the early operators who tended to "Merinize" names and distort their meaning. Mr. Mollet[3] quotes in particular: Manazary becoming Mananjary, Andovoranty (lagoons in a line) became Andevoranto (the slave market).

Or again, a certain number of places, in general coastal, long frequented by Europeans, have been Frenchified, the Malagasy form being easily re-established; the best known examples are:

Fénérive (Fenoarivo), Vohémar (Vohimaro), Tamatave (Toamasina), Tananarive (Antananarivo), Nossi-Bé (Nosibe).

Finally, some names are of foreign origin, either Swahili (Majunga?), or Arabic (in particular all place names such as markets relating to days of the week), or to a very small extent, European (Fort-Dauphin, Foulopointe, Sainte-Marie, Sainte-Luce, and the Like).

A certain number of places and tribe names have a religious, legendary and historic origin (e.g. the famous series: Fenoraivo—Arivonimamo—Mairinarivo—Fenoarivo which relates the adventure of the thousand who gather together, get drunk, pull themselves together and reunite).

Most of the place or locality names, however, have a directly geographic origin, whether they refer to topographical form or structure or to a topographical detail: Ivohibe (the great mountain), Bezavona (the very misty place), Betsiboka (there where there is much fresh water) Bongolava (heights in a line), Ambatomainty (the black stone), and so on, or whether they refer to the vegetation or the fauna: Amborompotsy (the place of white birds—ox-peckers), Analamanga (the blue forest), etc., or again to considerations of dwelling sites or prospect: Antanandava (the long village), Ambohibao (the new village), Ambohidempona (the village in the hollow), Ambohimahasoa (the village of comfort), and the like.

Owing to the low population density over a large part of the territory and to the small number of names linked with a historic or legendary past (except on the plateaux) the toponymy is in many regions rather meagre and offers, in consequence, many repetitions, either of topographical features, or of places, factors which are liable to cause confusion; in general, an attempt is made to remedy the situation by adjoining regional adjectives or adjectives of orientation, or even sometimes by using serial numbers in Roman figures. Undoubtedly, there is still much sorting and classifying to be done sometimes in face of acquired habits which easily permit combinations of terms of Malagasy and European origin, such as: Mananara-Nord, Ambohimanga du Sud, Midongy-Ouest.

On the other hand, in the present state of affairs it seems difficult to remedy the instability of the names of villages, which are often subject to displacement or even to disappearance, pure and simple, the consequences of local migrations of the populations accounted for by economic instability and certain prohibitive customs.

The most important point with respect to writing is that since the beginning of the 19th century the transcription of the Malagasy language—or more precisely of the dialect spoken by the Merina, which rapidly became the official language of the Island—has been practically settled[4] in Latin characters. The spelling adopted includes some

[2] Bearing in mind certain differences of pronunciation or sound; this has in particular recently led the Government to add two signs to the official spelling to give the sounds "gn(n̄)" and French "(ŏ)" which do not exist in the Merina dialect from which the official written language is derived.

[3] This study has taken several examples from his "Little Guide to Malagasy Toponymy" (IRSM. 1957) which is very well documented, particularly with respect to words of "coastal" origin.

[4] With the exception of the previously mentioned modification recently introduced by decree.

peculiarities of pronunciation, which are easily acquired with a little practice, but presents above all the great advantage of being practically univocal from the point of view of phonetics.

This simplifies, at the price of a little attention, transcription of the names collected orally by the staff responsible for surveys, guided in particular by the "Vocabulary of the words most commonly in use and principal geographical expressions of the Malagasy language, with their French translation", published and frequently brought up to date by the Geographic Service in conjunction with Malagasy language experts in the Malagasy administrative services and the Malagasy Academy. Before leaving their work areas the personnel must, moreover, have the spelling of the names collected checked by local administrative officials. These names are also compared with other sources (geologists in the Mines Department, surveyors in the Topographical Service, research workers in the Malagasy Institute of Scientific research, and the like. In case of any disagreement or discrepancy, a qualified authority on the Malagasy is consulted; administrative names are transcribed in accordance with the Official Geographic Code prepared jointly by the Ministry of the Interior and the Statistical Service.

A certain number of rules, however, still remain to be defined or specified, a task to which the future Malagasy Toponymy Committee must apply itself, being guided to great advantage by the rules recommended by the Group of Expert of the United Nations Economic and Social Council.[5]

The main points to be specified may already be outlined:

The preservation of regional forms of place or small locality names (large built-up areas being obliged to retain their present names);

The elimination of possibilities of confusion between identical or very similar names and eventual rectification of empirical methods in use;

The standardization of the use of the initial article I—in many place names—and stabilization of rules governing the use of the locative prefix "An", "Am", or its derivatives;

The fixing, if necessary, of comprehensive or area names of large geographic entities;

The translation into Malagasy of foreign names in cases where there are no preponderant reasons for their maintenance;

The compilation of a dictionary or complete geographical glossary.

[5] In particular by Economic and Social Council resolution 814 (XXXI) of 27 April 1961, a resolution which was the subject of an official reply to the United Nations Secretary-General from the Malagasy Republic at the end of 1962.

MEMORANDUM ON THE PRINTING OF MAPS ON RETROVYL IN FRANCE[1]

In many countries efforts are being made to find protective devices that will prolong the life of maps—to preserve them from the effects of humidity and heat.

Some advocate protecting maps by a coating of varnish or by placing them between two sheets of plastic; other use paper with a latex base or a base of some synthetic material which increases resistance.

One of the solutions adopted in France and which is likely to be suitable for the special climatic conditions of Africa is to print the map on a new textile called "Retrovyl", which is non-inflammable, water-resistant and resistant also to atmospheric or biological destructive agents, particularly insects and rodents.

"Retrovyl" is manufactured in various strengths (gr/m^2) and printed on an Offset machine just like any ordinary map, provided that it is fitted with a "stream" feeder and an efficient earth connexion to avoid the effects of static electricity.

A specimen of maps printed on "Retrovyl" was distributed to the participants and samples can be obtained at the Etablissement Blondel la Rougery, in Paris.

[1] The original text of this paper, submitted by France, under the title "Note concernant l'impression, en France, des cartes sur Retrovyl", appeared in French as document E/CN.14/CART/21.

A METHOD OF PRODUCING NEW PLATES FOR THE HOHLUX PHOTO LETTERING MACHINE[1]

By F. E. Rixon, Surveys of Kenya

1. In order to speed up the production of "type" for fixing on astrafoil "fair drawings", a Hohlux photo lettering machine was introduced in 1962 to supplement the existing Littlejohn letterpress. This particular photo type machine which is relatively inexpensive, photographs each required letter in turn from a rectangular glass plate —a separate plate being required for each type face. The developed image is on a transparent "stripping" film. The Hohlux has proved so successful that with it a 24 type service is now in operation, and the Littlejohn is utilised for other work.

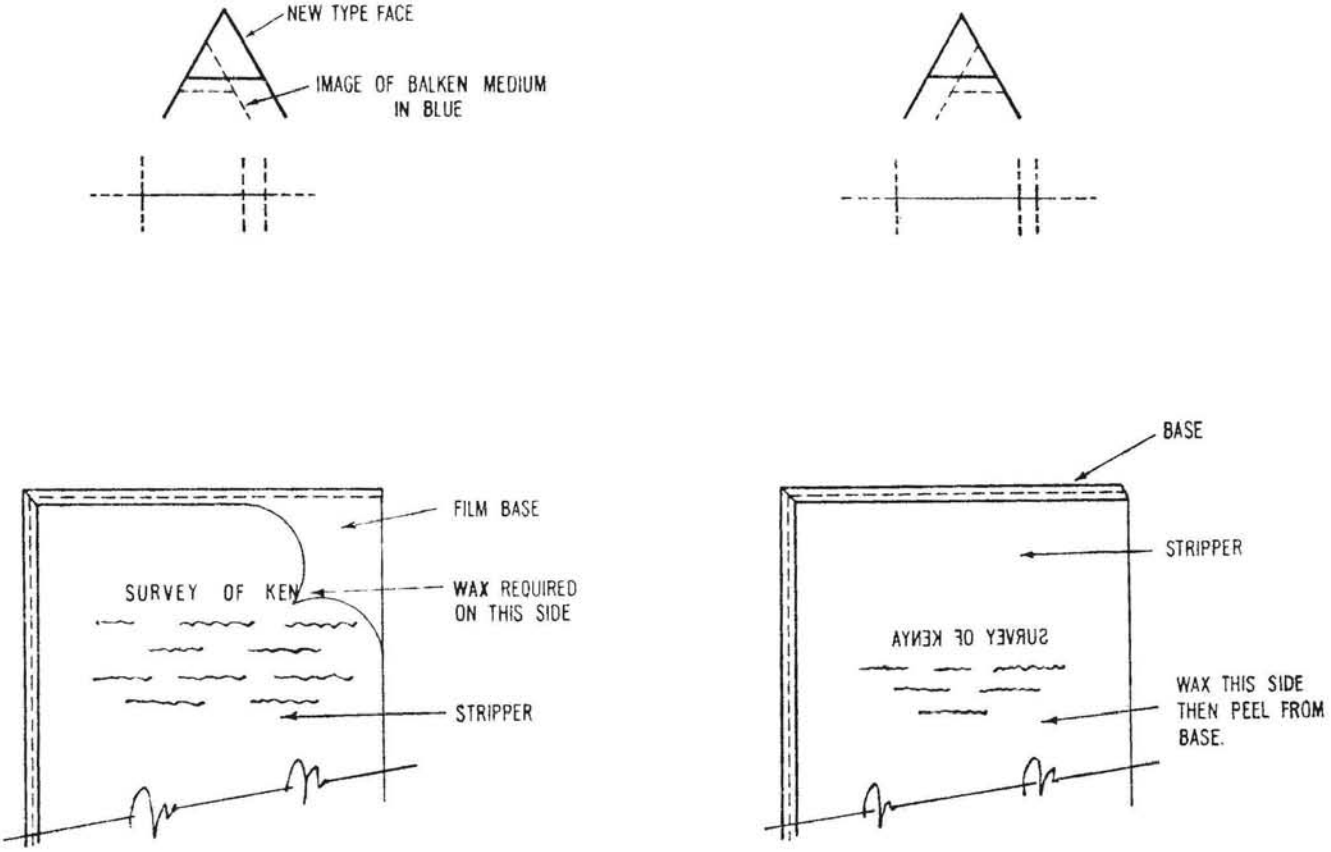
2. At the outset however, a serious drawback to it was the comparatively high cost of each type face on glass prepared by the manufacturers, and the absence of appropriate "faces" for mapping specifications already in use. To overcome this, experiments were made with the object of producing our own plates and the success of this work may be gauged from the fact that a complete range of type faces is now held for all possible mapping requirements, together with some less common faces for miscellaneous jobs. In addition, work is now in hand on plates covering the more popular conventional signs.

3. The method of producing these lettering plates varied slightly but basically was as follows:

(*a*) A good impression on paper, card or film of the particular type of face was obtained. The source was varied, "Lettraset" (a relatively new product—various alphabets etc. prepared as dry transfers) being used where available, but in most cases the required alphabet was taken from letterpress catalogues, magazines, etc. The letters were then reproduced on stripper film at a size equivalent to 2/3rds of the maximum size required by the map specifications currently in use in the Department for that particular type face. This size, of course, varied with each face depending on its intended use. (The Hohlux will reduce and enlarge between the range of 0.21 and 1.5 of the original or plate size.)

(*b*) Meanwhile, a contact blue on astrafoil was made from the plate (Balken Medium) supplied with the machine. Using the lower half of the astrafoil blue as a guide, the letters on stripper film were waxed and placed

[1] The original text of this paper, submitted by Kenya, appeared as document E/CN.14/CART/39.



Method of producing new Holux plates

in the correct position. The left and bottom extremities of the new type were placed directly over the corresponding points of the appropriate letter on the "blue". This operation was carried out with extreme care, as the slightest deviation from the "blue" would result in an inconsistent level of letters on the type setting.

(*c*) Next, the guide lines for correct type spacing were drawn, this being probably the most tedious aspect of the work, and some trial and error was necessary before the correct positions were found. With the left and bottom extremities of the new letter coincident with the similar positions on the "blue", the left-hand guide mark was the same as on the specimen plate supplied (see fig. 1). For the right-hand marks, the astrafoil was then positioned over a copy of the specimen plate in such a way that the right and bottom extremities were directly over their counterparts on the original plate. The right-hand guide lines were then traced from that plate (see fig. 2), and the process repeated for each letter in turn.

(*d*) The next stages were concerned with the reproduction of the astrafoil in positive and negative form. These were carefully butt joined together, using the original plate as a guide to position in the reverse order of the finished plate, so that the negative was at the bottom and positive at the top. This, when contacted on to glass resulted, of course, in the negative and positive being reversed in layout.

(*e*) The glass was cut to the correct size and then tested on the machine for accuracy of the layout and position of the guide marks. As a result of the tests, minor modifications were made to the guide marks on the glass, where necessary.

4. The plates prepared by the manufacturer read A, B, C, etc. from left to right, with the developed film, of course, reading the same. This does, however, result in the problem of removing the stripper from its film base before it can be waxed. The stripper being so flimsy, this process (see fig. 3) often resulted in the stripper becoming torn and distorted when applied to the waxing machine. To overcome this, the glass plates were reversed so that when set up in the Hohlux machine, the alphabet reads from light to left, and consequently the developed stripper is also in reverse (see fig. 4). The film can then be waxed on the emulsion side whilst still attached to its base, thus preventing any tearing or distorsion. The waxed side is then covered in the normal way with paper, and when lightly fixed, the film base is removed.

5. It is believed that by carrying out the work of preparing these plates within the department, many hundreds of pounds have been saved, whilst at the same time, providing a really fast and economical type service which has permitted cartographers much greater flexibility in map design.

DEVELOPMENT OF MAP REPRODUCTION AT THE SURVEY OF EGYPT, U.A.R.[1]

The lithographic process of printing a coloured map used at present by the Survey of Egypt is in two stages:

(*a*) Preparing printing plates from negatives made from basic colours of the map such as geographical details, contours, names... etc.

(*b*) Where maps contain colour layers, a key plate is made from the appropriate negative before touching up. A number of set-offs are pulled from this negative. These set-off plates are worked up by hand for each colour. This involves a considerable amount of work, particularly where several colours are needed.

The use of half-tone screen was recently introduced at the Survey of Egypt to replace the set-off work and to reduce the number of printing plates. The half-tone screen is a grating of opaque lines on glass, most commonly, crossing at right angles. When a continuous tone original is to be reproduced lithographically, the half-tone screen is placed in front of the negative at exposure. It thus translates the original continuous tones into broken tones or gradations of dots. In other words, the half-tone process is the reproduction of continuous tone copy into a grid of fine dots of varying sizes to represent appearance of continuous tone on printed sheet. Some geological maps in colour were printed in the Survey of Egypt using half-tone screen when photographing the originals instead of making them by hand on set-off metal plates.

The limitations of half-tone screen in colour reproduction are as follows:

1. The maximum size available at the Survey of Egypt is a disc of 80 centimetres diameter. This limits the maximum size of work to be photographed. Some printing machines at the Survey of Egypt can take plates with maximum size of work of 78 × 106 cm.

2. The originals which must be prepared for half-tone screen work need highly skilled draughtsmen to ensure evenness of tone layers as originals should be done in grey tints.

To overcome these difficulties, the writer studied the possibility of using commercial pattern transparencies to imitate the impression obtained by half-tone screen and at the same time to avoid the limitations of this process. In the course of these studies the commercial transparencies known as Zip-a-Tone were used.

Zip-a-Tone sheets contain vast variety of patterns: dots of different sizes, parallel straight lines, cross lines, different kinds of trees and references, etc...

This kind of material is backed with adhesive substance. It was made to provide the cartographer with ready-made patterns for shading instead of drawing the patterns by hand on the original sheet. Amongst the different patterns of the Zip-a-Tone sheets there are several dot shades in percentage grades of the solid black starting from 10% up to 80%. This gave the idea of the possibility of using Zip-a-Tone dots in place of the half-tone screen by using lower percentages to print light

[1] The original text of this paper, submitted by the United Arab Republic, appeared as document E/CN.14/CART/73.

shades and higher percentages to print darker shades. The same principle was applied to reproduce combined colours such as the different shades of brown, orange, green and violet colours.

The studies led to the development of a technique to reproduce the required colour from the combination of three colours: yellow, red and blue together with the black.

ADVANTAGES OF THE ZIP-A-TONE PROCESS

1. Three plates, together with the black base plate, suffice to produce a map with a large number of different coloured areas;

2. The process dispense swith all hand work previously needed for the preparation of printing set-off plates;

3. In case a printing plate becomes worn out a new plate can easily be prepared from the negative;

4. The process enables us to make use of the maximum size of work offered by our printing machines by simple line work photography.

[EDITORIAL NOTE. *This article was followed by an interesting example of the use of the Zip-a-Tone for the printing in colour of a map of Africa. It also gave a table showing the formation of the different colours by the combination of the four basic colours: black, red, blue and yellow. Unfortunately, for technical reasons, it has not been possible to reproduce these multicoloured plates. A limited number of copies of the original article are available on request*].

PREPARATION AND REPRODUCTION OF MAPS[1]

Part one

APPLICATION OF MAPS

1. INTRODUCTION

Most surveys are left in the form of figures and sketches in note books or rough drawing sheets and filed away in the projects' archives, forever beyond the reach of all who would have used such valuable information had they been converted into conventional maps and reproduced in large quantities for distribution. This introductory portion therefore seeks to emphasise the need to prepare maps and reproduce them. It also urges those who would prepare maps for national development to strive for the establishment of a centralized national mapping service as the most effective way of preparing and reproducing maps. It also sites a number of examples of the uses of maps so as to show the range of usefulness of our maps and so prove that the National Mapping Service should function as an independent organization, free to serve all alike. This achieved, the text continues with the techniques of the mapping and reproduction procedures. This text therefore may be divided into three sections: (*a*) part one covering introduction of the subject and examples of application of maps; (*b*) part two covering the structure of a mapping organization and instruments and methods used in preparation and reproduction of maps; and (*c*) part three covering correlation of the mapping activities with users requirements and distribution methods.

2. WHY MAPS?

2. (i). Maps are the final form of presentation to the public of data which would give them information of the configuration of sections of the earth's surface together with other statistical data which vary by geographical zones on the map and which could be represented numerically or pictorially. Maps therefore are prepared either for wide range use or for specific purposes.

The office which prepares the map may be centralised and so provide for extensive reproduction and distribution or it may be attached to a specific project and remain in the form of rough drawings which would not be distributed. It is important therefore in considering the subject of preparation and reproduction of maps to dwell first on the type of map-making agency and to show the feasibility of having first a centralised national mapping service. In this attempt it would be well to include examples which should indicate the range of usefulness of maps.

A greater amount of reproduction is required of maps which are for general usage and it is only maps of this type which when sold would cover the expenses involved in the reproduction phase. The expenditure involved in the collecting of information and preparation of the maps, however, are generally justified by the benefits the community derives from the use of the map rather than from the cash sales of the printed sheets.

All engineering projects must of necessity be executed with information derived from maps. The tendency has been for each project to begin with elaborate surveys and map preparation in order to achieve the basic data needed. In some cases this preliminary cost totals as high as twenty-five per cent of the cost of the project and requires personnel who are not trained for the construction of the project itself. Moreover, as these maps are prepared for a specific project, the extra cost necessary for the neat drafting and printing of the map for general distribution is often considered unrelated to the project. This economic consideration inherent in each contract results in the storage into the projects' obsolete files a series of valuable information in the form of field notes, sketches and rough drawings which are not properly filed, and are often dumped as rubbish after the project shall have been completed. They could not however have been printable for distribution in the stored state because they were not

[1] The original text of this paper, submitted by Liberia, appeared as document E/CN.14/CART/81 and Add.1, under the title "Preparation and reproduction of maps". For better integration into the present report, the original paper has been divided into: "Preparation and reproduction of maps", "Ten years achievement of the Liberian Cartographic Service" (see agenda item 6) and "Proposed Reorganization of the Liberian Cartographic Service" (see agenda item 7).

drawn according to conventional standards which could be understood by the public.

2 (ii). Those wishing to prepare and reproduce maps most economically should be convinced, of the need to influence those responsible for budgeting, concerning the obvious waste involved in placing priorities on the mapping of an area, simply for the specific project involved and so budgeting the mapping as part of the figure provided for that project. Considerable use is made of maps in the planning and design stage prior to arriving at the final estimate to be budgeted for the project. The need for the existence of maps before ever considering whether or not a project may be undertaken makes it imperative that there be a map-making organization existing mainly for the purpose of making maps. In order that expenditure on such an organization be made feasible, those wishing to prepare and reproduce maps economically must convince the Budget Bureau that they should not reckon in terms of expecting a direct benefit from the sale of the maps. This initial step of the would-be map maker is very difficult as the maps does not present at first sight a grand spectacle as would a building, a beautiful garden, a farm, a lumbering scheme or a hydroelectric plant. Moreover, only few people can readily be convinced that they just cannot have all those amenities without first having maps. Further, as the cost of mapping procedures, to meet all demands simultaneously, requires a considerable expenditure as compared with any one of the projects requiring it, it is never probable that an adequately financed national mapping office can be established as a branch of any specific short range or long range project. Indeed no director of a project would be able to get appropriation for one of his many sub-branches in an amount axceeding four times the combined appropriation of all the other branches. It would therefore be better to urge that national mapping be financed as a unit benefiting the public in general.

To achieve adequate financing requires vigorous advertisement. To name such an organization the National Cartographic Service would be applying the more appropriate terminology for naming a comprehensive mapping service which would be responsible for getting the horizontal and vertical control and for majority if not all of the observations and investigations needed to procure data to be presented on the map. To support this we quote the definition of cartography from the Technical Dictionary: "Cartography—the science and art of expressing, graphically by means of maps and charts, the known physical features of the earth's surface, and often including the works of man and his varied activities. Specifially, cartography is the art of map construction and the science on which it rests. It combines the achievement of the astronomer and the mathematician with those of the explorer and the surveyor in presenting a picture of physical characteristics of the earth's surface. It invariably includes assembly, evaluation, selection and rejection of data."

Those wishing to prepare and reproduce maps on a national scale might first seek to get adequate appropriation by educating the public on the benefits of maps.

3. PRACTICAL APPLICATION OF MAPS

3 (i). Maps provide the public with data in cartographical language for evaluating and programming construction projects as well as for agriculture, natural resources, exploration, inventory and exploitation, navigation, census, national sanitation and even deploying of military forces.

Mapping procedures would have to be undertaken in two phases: the long term phase and the short term phase. It is in the long term phase in particular that the need for a centralised national mapping service is more apparent. The long term phase is that which covers the entire country in one comprehensive system. It requires extensive field surveys, electronic measurements, astronomic triangulation extending over the entire country to form a framework for horizontal and vertical control for the entire country so as to have every part of the country expressed in the same integrated coordinate system.

Along side with this in the long range programme is the over-all topographic mapping which will be tied into the framework of the horizontal, vertical and gravimetric control. The hydrographic mapping tied unto shore-line details in the same integrated coordinate system will also be executed along lines of this long range programme. This long range programme will require a budget and personnel exclusive to itself to make it a continuous process providing data that would permit preparation of maps to constantly larger scales, as well as actualising old maps needing revision.

As the maps of the long range programme are produced at still larger scales they provide data for deciding on a greater range of projects which must be provided with futher information appearing on extra-large-scale maps produced on short range programmes for the specific project.

In order to develop the series from the comprehensive long-range over-all topographical maps to the extra large-scale short-term specific purpose maps for national development, it is necessary that the most up-to-date methods be used. Photogrammetry combined with electronics have made it possible for mapping to precede economic development and so permit a more rapid economical expansion of the national economy.

3 (ii). Mr. H. Hemming, in the "Mine and Quarry Engineer" quotes Sir Gordon Guggisberg as stating that half a million pounds had to be spent in straightening a railway line in the Gold Coast (now Ghana) because no photographic maps were available at first. This recognises the fact that a photographic map shows every feature in the terrain as opposed to what C. A. Hart calls a "plum pudding" map made in the old conventional way with black areas in various parts. R. Bourne of Oxford University referring to Northern Rhodesia recommended, for such type of development, a general air reconnaissance of the country, and this he considered should repay the cost in a hundred ways.

3. (iii). Whether or not the exploitation of natural resources and urban development would take the proper pace depends upon the type of maps and cartographic services available. Investigations and exploration costs can be so high, and the task so long and tedious, that investors may often shrink from a lucrative venture, and the countries' economy be thereby retarded. Yet with

adequate maps and modern cartographic facilities every information can be brought to the investor in so short a time and at a cost so low as to encourage investments that otherwise might have been postponed for several decades. Investigation made in the United States of America have shown that having topographic material available can reduce planning costs by seventy (70%) per cent. The records give us a number of clear examples and reports underlying these experiences. For example, an industrial area in the State of North Carolina lost ten million (10,000,000) dollars because new industries preferred to settle elsewhere owing to the lack of maps with contour lines.

According to another American source, the importance of maps was clearly demonstrated in planning a highway sixteen (16) miles long. Five thousand (5,000) dollars were spent on three local surveys and then the costs were estimated in the usual manner. Before starting the construction work, a topographic map was produced at the price of two thousand two hundred (2,200) dollars. By use of this map a new road-bed was chosen, and as a result, the construction costs for the highway diminished by two hundred thousand (200,000) dollars as compared with the original estimate. In another case a railroad company economised eighty-five thousand (85,000) dollars by changing the planned road-bed of a railroad track after studying a topographic map. These figures are supplied by the Co-operative Society for Geodesy and Cartography, Frankfort, Main, Germany.

3 (iv). Indeed the economists, city planners, geologists, highway engineers, architects, agriculturists, sanitary engineers and all design engineers demand topographic maps as a priority for economic development in the quickest and most economical way.

Before closing this introductory chapter on the practical application of maps we must be reminded that it has been intended principally to stress the importance of maps with a view to getting the desired budget to perform the mapping and to reproduce the maps. C. A. Hart of London University states that as the exchequer benefits only indirectly from reliable topographic maps, the tremendous costs for air survey which must be spent in a lump sum could be denoted by the various departments directly concerned, such as survey, public works, geological survey, forestry and agriculture. While not disagreeing entirely with this method of collection we would recommend that these users of the finished map rather petition the exchequer to allocate the funds directly to the centralised mapping service out of cuts made from their respective departments. A typical handicap involved in the former recommendation can be gathered from a study of ranges of mapping done by different agencies. The trend has been in favour of whatever department was capable of getting the most appropriation thereby tempting them to do the mapping themselves.

3 (v). Thus the U.S. Bureau of Soil Conservation, according to C. A. Hart, has mapped from aerial photographs a greater area than other Bureaux normally expected to be in charge of mapping. In some countries it is the military offices and in others the Forestry Service. Some advocate that most of the mapping is connected with the bureau responsible for real estate tax collection. This latter situation however takes the type of mapping done too far from the needs of developing countries particularly in Africa where the emphasis for a long time would be on the exploitation of natural resources and on engineering construction. In addition to this it should be noted from D. Hendrick on "cadastral mapping" that "The cadastral surveyor is mainly concerned with placing and re-establishing of beacons. This is a field operation and cannot be done by aeroplane." He continues by adding that even in the developed parts of Africa there is no practice of marking property with hedges and ditches hence the boundary lines do not appear on the photographs even if they had been marked by cairns which is the farthest advance in property delineation in the developed areas.

C. A. Hart states in this connexion that there seems to be some confusion of terms as to what exactly a cadastral map is. In Africa there are vast uninhabited areas between settlements making it unnecessary that cadastral plot plans be integrated. Yet some influential citizens might advocate placing the national mapping service under the cadastral office. This step should be vigourosly objected to by those wishing effectively to prepare maps, since few cadastral chiefs can be made to see the urgency for a national horizontal and vertical control framework as basis to the national mapping.

3 (vi). Because of these considerable difficulties in getting a mapping service funded as it should in order to produce the best results, it has been deemed necessary to devote such great emphasis on the need to educate the public on the value of maps as the primary point in the preparation and reproduction of maps.

3 (vii). Thus the Short Range Services would entail participation in the current research, exploring, programming, planning, layout, construction and exploitation undertaken by this office in assistance of all other Departments of Government or sections of the community. The following are examples:

3 (vii) (*A*). The agriculture section may have a programme for reclaiming vast swamp areas for paddy rice cultivation. It is the maps produced by the long range programme which will point out to the programme planning officer the location of the large swamp areas, the extent and economy with which they can be reclaimed, their accessibility to existing power supply or resources, roads and markets and the location sites for access roads and lines of communication. Having aided in the selection of sites, the next stage of our participation would be the preparation of large-scale topographic maps which would point out to the design officer where he should place his dam sites, his drainage and irrigation ditches, (polders and busoms), his roadways, power and telephone lines, silos and graneries, power plants if necessary, workshops, packing, receiving and dispatch stations, headquarters offices as well as housing facilities for the workers.

(*A*-i) If the project is large enough, or the group of the satellite projects (oil production from vegetable fats and livestock) in the general vicinity bring together sufficiently large bodies of workmen and their families and traders, such a state of affairs if visualised at the programming stage could be planned for, simultaneously with the

planning of the rice production project. In this case the long range over-all topographic map would again have to be referred to for selection of the site of the City and access roads for this growing community. Again the design officer would need another short-range project for preparation of a large scale topographic map which would serve as a pointer to the proper location of streets, boulevards, overpasses or clover-leaf-road-junctions, schools, hospitals, churches and public administration and judiciary offices to maintain a civic centre for the various settlements, thereby furthering the cause of the rice production through the facilities that would encourage the workers to remain in the neighbourhood and even make it their permanent home.

(*A*-ii) At this stage after having visualised, programmed and planned eventualities, of the project, and having obtained approval and financing, the planning section would then send the plans to the design section of the Engineering and Architectural Services Division for proper design of each of the members so planned. After this is completed then the occasion might arise to lend out one or a few semi-skilled surveyors for the layout, grading, checking and landscaping. As this phase is generally done on constructual basis and as the layout and inspection methods require the use of only low precision and semi-skilled personnel in very small groups or as individuals, it might prove more economical to maintain a separate staff of semi-skilled surveyors for this purpose. Certainly, this latter procedure would be found necessary after a costly experiment to the contrary. It is therefore recommended that a rigid Executive ruling be sought to prevent the intermediate chiefs from becoming so overbearing as to requisition, for layout the members indispensable to the long and short range mapping programmes. This Executive ruling would also place a ceiling on on the number of individual arbitration disputes on which the Bureau may be pre-occupied. Unless the present pre-occupation of experts on layout jobs is curtailed and disputes assigned entirely to the Cadastral Survey sub-section in the Division of Surveys and Planning it would be virtually impossible to apply the requirements of this report for centralised Research and Programming. Experience in the past has proved that long or short-range mapping programmes tive have seldom been completed successfully and highly trained surveyors had to leave their respec-projects to meet individual property demands only to discover on resuming the project that they have to continuously recommence re-establishing stations, that have been uprooted, and field notes that have been scattered.

3 (vii) (*B*). Before proceeding to the phase of correlation with the allied sections, we should mention a few more examples of short range projects. The Power Authority for example might want to use hydroelectricity and so require the building of a dam at the best site. This again would require initial reference to the long-range over-all topographic map to determine the area of the drainage basin as far as the various sites selected on the basis of the existence of the waterfalls and the presence of hills on each side of the fall-site making it feasible to plan a higher dam. Next, the climatological map will help to determine the amount of water that will be held back within a given period over the drainage area, and again provide a factor for determining how high the dam will be. Information from these maps will show the area and approximate value of development to be affected by the flooding and so provide further data, cartographically expressed for the programming and planning of resettlement schemes. Population density maps will provide further data. Population figures could also have been derived from graphical representations on the topographic map. After selection shall have been made on a number of possible dam sites, the short-range extra-large scale topographic mapping project would again have to be executed for these possible sites, to provide more detailed information toward the final selection and design in a manner explained in consideration of the rice project. In this case, however, core drillings would have to be made and findings expressed cartographically on a geologic map of the sub-structure for foundation studies in the design of the dam.

3 (vii) (*C*). As another example, we might be faced with the demand from the Mining section of the DAC for the construction of a highway and a railroad to a newly discovered rich iron ore deposit. Here again the initial reference would have to be made to the long-range-topographic map. Contributing factors for selection of the road site taken from this map would include the number of communities the road would service, the productivity of these communities, the urgency of getting commodity exchanges between the places and the harbour. While these considerations are intended to satisfy the maximum use, they must be considered secondary to the other visible map features of contour of the terrain, so as to minimise the number of sizes of bridges and at the same time sharp curves and gradients. The selection of the railroad bed sites would be considered among a number of central valley lines in the general direction of the iron ore deposits and the most economical sites for tunnelling into the mine if such prove necessary. After this type of selection has revealed a number of possible sites, they would have to be re-mapped at much marger scales to provide further data for the final selection of the actual site for the calculation of the volumes of earthwork on cuts and fills and for the design of bridges.

4

Other types of short range projects would include our participation in providing data, cartographically expressed, in connexion with the exploration of oil minerals, and forest resources. We also include the pressing individual needs of re-establishing corners of lands described in old deeds made decades ago and so aid the Department of Justice in settling disputes. In this latter case, it must be always remembered that whenever projects

of the previously mentioned types are on hand, they must be given priority as they render simultaneous service to a much greater number of people.

Part two

Organization methods and instruments

5. Data used in preparation and reproduction of maps and how acquired

5.1. What appears on the map is indicative of the data used. A map shows a set of rectangular grid lines on which are drawn geographic curved lines on which appears symbols which show the shape of the terrain and other features of human development.

5.2. The grid lines are drawn by coordinatographs on beam compasses, according to scale. The points on longitude and latitude intersections at certain intervals are plotted from given rectangular coordinates available in table books of the particular projection. These points when joined form the curved lines simulating in projection at a reduced scale, the imaginary latitude and longitude lines on the earth's surface. The Projection used is selected according to the purpose for which the maps are particularly needed. Certain projections as the Mercator (cylindrical) projection enable navigators to measure directions easily but distort the shapes as the distance from the contact axis increases. The Hotines polyconic tables are called ortho-morphic because they facilitate the plotting of geographic lines on a flat surface between which can be drawn a diagram of the terrain in a way as to show its correct shape. The Mapping system of Liberia is based on this latter projection.

5.3. Spherical coordinates of points on the ground are plotted in their respective positions between the geographical lines using the rectangular grids as reference and the tables for the plane coordinates of the geographic positions. The geographic positions of each of these points had been listed after adjusting a series of observations made at the actual points on the ground. These observations were often made on heavenly bodies and the observed positions compared with their corresponding predetermined positions at the same instant at another place. These reference positions are derived from tables of apparent places of stars. Observed positions have to undergo a series of corrections before they would represent the what should have been true values. Extreme accuracy in corrections demand time and equipment that makes it more feasible to have such points far apart and connected to intermediate points derived by other methods. Very accurate positions of ground points for plotting on the map sheet are derived from observations of angles or distances extended connected over vast distances and making it possible to calculate the positions of the several inter-connected points on a common datum. Other methods in this category include spatial triangulation of points on oriented vertical aerial photographs or by electronic measurements made from the aircraft at the moment of camera exposure to known ground positions.

5.4. Having plotted these control points on the map sheet, sections of geographic details like shore-lines, mountains, lakes, rivers, roads, and man-made features surrounding these control points are adjusted within the framework of the plotted control points. This insertion is accomplished by one of several methods. Primarily, the positions of the details are established by numerical coordinates of points to be joined whose values are coordinated with the control points that have been referenced in the same system as the map grid lines through known geographical coordinates. Often these details are plotted to the same scale, projection and orientation, and traced. Graphical or photographical information have to be first rectified and reduced to orthogonal projection before being used as a source of information. With improved photogrammetric instruments, the rectification, orientation and plotting of topographic details with contour lines around the control points are made simultaneously.

The maps symbols are taken from internationally standardised conventional symbols. The correct spelling of the names of places, however, have to be standardised by a National Geographic Names Board and those spellings approved by the Government in advance before being applied.

Some maps show additional information other than topography with contours. These too are suggestive of the sources from which data is derived. The following are a few of the various types of maps which use either planimetric or topographic maps as the base on which the additional information is drawn: geological maps, climatological maps, population density maps, soil texture map, soil moisture maps, forestry types and density maps, commodity available and marketing maps, drainage and irrigation maps, communication maps, hydrographic and aeronautical charts, wild game types and density maps, military maps, tourist maps, cadastral maps, crop distribution and land use maps, and maps for design and layout of highways, dams, bridges, buildings, parks and all engineering projects.

6. Structure of a mapping organization

The next step when considering the subject of preparation and reproduction is the consideration that it must be carried out in a well-organized bureau for it to be carried out effectively. There is so much involved in mapping for a nation that the Bureau must apply the soundest principle of organization. From the foregoing chapters, it will be seen that it is necessary that National mapping be centralised. The last chapter gave a rough outline of what is involved in the mapping procedure. With these in mind, the following structure of the national mapping Service should appear feasible.

6.1. There should be three sections of this service, namely: (*a*) planning, data collection and examination, production and actualization; (*b*) reproduction and dissemination; (*c*) correlation and application.

Planning, data collection and examination, production and actualization would entail collection and grading of existing data and securing further information by application of techniques in Geodesy, Aerial Photography, Photogrammetry, Hydrography, Cartography and field checking and adapting the information to the requirements of all phases of economic development that might make

use of information which would be pictorialised on maps. Among these we might include geological, soil, and forest exploration and exploitation, as well as planning and lay-out of projects for human welfare, cadastre and remembrement. Much of the work done in this phase must be performed in air-conditioned chambers and the equipment preserved in low-temperature and low-humidity storage compartments. Ample travelling facilities should be provided for field crew and sufficient space for office personnel. The administrative section of this Service must be of equal efficiency as the purely technical section, so as to be of assistance in evaluating time-and-motion studies to enable production to meet the dead-line. A geographic name board should determine standardised spellings for all places in the country.

Reproduction sections are always necessary adjuncts to the Cartographic Service. Preparation of photostats, enlargements, blue prints and offset prints are expected to be done in this section. For large quantities of duplications or for large-sized prints, however, it might be advisable to work in coordination with the government printing services or with commercial printing firms. Dissemination of information could be effected through coordination with the users directly or through sales agencies and advertising in engineering journals.

Correlation and coordination between the activities and facilities provided by the Geodetic and Cartographic Service should be made with all organizations likely to use these facilities or to contribute pertinent data in geodesy and cartography. These related organizations would include the real estate or Cadastral Office through land registry; the Bureau of Soils, Irrigation and Reclamation; the Forestry Service; the Geological Service; the Armed Forces Mapping Service; the schools, through atlases; the municipal construction services; the rural resettlement agencies; the economic planning agencies and all others so related.

One branch of the National Cartographic Service would have to be devoted to demonstration of the best possible application of maps in each type of economic development.

6.2. This organization as outlined would have the following main branches:

(*a*) The office of the Director;
(*b*) The Division of Geodesy;
(*c*) The Division of Photogrammetry;
(*d*) The Division of Photography and Reproduction.

Each of these divisions should have an on the job training section.

A specially designed building is required and much of the work has to be done in air-conditioned chambers. Delicate instruments must always be stored in de-humidified chambers and photographic supplies at very low temperature.

6.2(*a*). *Duties of the Director's office* cover three main phases, namely, (1) technical; (2) supervisory; and (3) administrative. Each of these phases has two branches: field and office. Broadly, these duties are as follows:

Technical

These duties require a technical insight into every area of activity necessary for the acquisition of data from field and photogrammetric sources and into every area of activity in preparing topographic, hydrographic and all types of maps, their printing and distribution. These technical activities are listed on the sheets showing functions of the Liberian Cartographic Service. He must "get on the job" himself and perform these tasks in every area in which additional hands are needed. He requires an educational background and years of continuous experience, in all phases of geodesy and cartography to perform the task ahead.

Supervisory

In addition to these technical aspects, he must save some time to look into the supervisory aspects. Each day he must check into the over-all advancement of each project on its way towards completion and assign personnel to new phases of the project to hasten completion before the dead-line. This phase must be pictorialised on progress graph sheets for the information of all concerned. Plans have to be always on the way for new projects. Tabulations have to be made for this re-assignment to another project as soon as his previous assignment is being finished. Contact has to be made with the public and government bureaux and agencies on their cartographic requirements.

Administrative

Administrative duties involve checking and helping those responsible for time-and-motion studies, budgeting, selecting, requisitioning and purchasing of equipment and supplies, grading, discipline and payment of personnel, and all other administrative matters listed on the attached sheets.

Specifically, these duties are as follows:

Technical—field

Turning angles, chaining, measurement electronically. levelling and performing all other field functions necessary for establishing First Order horizontal and vertical control. Computation and adjustment of level, triangulation, trialateration and traverse networks. Monumenting and referencing of all bench marks and stations.

Making plane table and tacheometer and other types of surveys for photography, contouring and all other types of data presentations for the economic development of Liberia. Filling in planimetric gaps and actualising old maps whenever such features are not visible on photography due to forest coverage or gaps. Processing notes:

Building of triangulation towers. Applying all other techniques in geodesy. Performing all other types of field work as listed on attached L.C.S. organization chart and the sheet explaining the functions.

Technical—office

Collecting, grading, processing and computation of all available information from office and field sources. Adjustment of positions. Plotting notes. Extension of horizontal and vertical control by aerial triangulation. Applying the other techniques of photogrammetry and aerial photography on functional sheets. Plotting details from metrical photographic projections.

Plotting contours from rectified three dimensional photographic models.

Superpositioning of statistically calculated data for all branches of economic development.

Superpositioning of useful but statistically undeterminable data. Rectifications, colour separations and checking preliminary to printing.

Final preparation and inspection of "Kodalith" and such types of negatives for offset printing.

Printing of cartographical data.

Filing and indexing of maps.

Supervisory functions

Scheduling and checking of assignments. Field checking of all data. Determination of adequacy of observed data.

Re-surveys for correction of faulty points.

Checking and correction of computation.

Analysis and evaluation of collected data and programming for extension.

Supervisory—office

Scheduling and checking of assignments. Checking and correction of smooth sheets and field computations. Checking and seeing that all collected data are checked and screened. Checking stereo-photogrammetric plottings.

Arranging with other offices for additional assistance whenever needed.

Supervising registration and grading of all cartographic information.

Performing all other supervisory functions on the attached functional sheet.

Administrative—technical

Drawing up plans and schedules operations.

Preparing flight plans.

Assigning personnel to projects, applying the principles of Ergonomics.

Running training programmes to increase personnel efficiency.

Drawing production flow charts to acquaint personnel of related functions.

Drawing progress graphs to show rate of progress and so determine the need for increasing or decreasing personnel or the entire machinery in light of costs and the deadline.

Maintaining files on personnel efficiency.

Maintaining files on instruments availability and placing new orders.

Serving as liaison with public, and with government on their mapping requirement.

Ascertaining ways and means of promoting long range and short range projects in areas that are due for immediate rapid economic development.

Maintaining contact and giving assistance to all map using organizations and projects.

Performing all other types of technical administration on the attached functional list.

Administrative—fiscal

Maintaining files on time and attendance of personnel.

Maintaining files on sick and annual leave of personnel.

Seeing to it that personnel are paid on time.

Seeing to it that personnel receive their allowance on time.

Performing all other types of fiscal administration on attached functional list.

6. 2 (*b*). *Functions for the Geodetic Division.* These cover:

(1) *Field records:*

The critical examination of the records, computations, description, and reports of field control surveys immediately upon receipt in the office; the reproduction of reconnaissance description; the checking of reconnaissance data as to its completeness; filing of all triangulation data, the editing and preparation for printing of all description of triangulation stations and bench marks; the preparation of sketches showing triangulation schemes and lines of levelling and the processing or requests for triangulation data.

(2) *Gravity and astronomy:*

Computation of astronomic observations of longitude, latitude, and azimuth and of gravity determinations; computation of laplace azimuth for Triangulation Section; recommendation in regard to field work such as location of stations and changes in method; isostatic reduction of gravity stations and definitions of the vertical; miscellaneous computation involving the principle of isostasy; research work involving all activities of the Division but especially in physical characteristics of the earth, the figure of the earth, and the variations of latitude; furnishing of information and preparation of manuals of office and field methods.

(3) *Triangulation 1:*

Computation of adjustment of triangulation, traverse, base measurements and trigonometric levelling; investigation and computation of related and scientific and technical problems including geodetic cartography; furnishing information to Government agencies and the public regarding the theory and application of geodetic data; consultation with local Governments regarding local control surveys and county-coordinate system; operation of I.B.M. unit for selected scientific computation related to survey data for the Bureau; preparation of manuals of office and field procedures; general supervision of the editing of technical scientific publications and articles of the division, and their publication.

(4) *Levelling 1:*

Computation adjustment and publication of levelling observations; furnishing information thereon; research work in geophysics and other researches leading to improvements in instruments and methods; recommendations for planning the details of new levelling projects; preparation of manual of office and field methods.

(5) *Triangulation 2:*

The extension of horizontal control which include

reconnaissance; the measurement of base lines, the erection of signal towers and triangulation observations. These furnish data for determining the latitude and longitude of stations and the true directions and accurate computed length of all the lines. The compilation and preliminary computation of field results on standard forms which are later used in the office for making adjustment. Reduction of measured distances to sea level equivalent.

(6) *Levelling 2:*

The extension of vertical control which include the establishment of permanent bench mark throughout the country and the determination of their elevations by spirit levelling of high precision; the compilation and preliminary or field computation of the results on standard forms for office use in making adjustments.

(7) *Gravity 2:*

Determination if intensity of gravity at stations distributed over the country for use determining the exact flattening of the earth, in making isostatic investigation for the earth's crust and for other purposes.

(8) *Astronomy 2:*

Observations of astronomic longitude, latitude and azimuths at triangulation stations for the purpose of obtaining true or laplace azimuths to be used in the adjustment of triangulation and of determining the deflection of the vertical figure of the earth's computation and for isostatic observation of the earth's crust.

(9) *Variation of latitude:*

The continual operation of the variation of latitude observation: furnishing the results to the International Commission on the Variation of Latitude.

(10) *Computing office:*

Computation and adjustment of triangulation, traverse, base measurements and levelling, computation of place coordinates: preparation of descriptions, geographic data and elevations of survey monuments in manuscript form for lithoprinting.

(11) *Equipment:*

Supervision of maintenance and repairs of equipments and boat. Maintenance of complete record of boat equipment data. General safeguard of interest of the Government in connexion with contracts, leases, and purchases, setting up priorities requirements and supplies needed for bureau (field and office).

(12) *Hydrography:*

Study of extending coastal surveys and of the needs for additional surveys. Preparation of instructions for surveys, including triangulation, hydrography, topography, levelling as necessary, and preparation and compilation of data for field parties. Supervision of field works of accomplishments of field parties. Study of cost, methods and processes of surveys.

(13) *Radio-sonic laboratory:*

Testing and checking operation of supersonic echo-sounding equipment and adapting equipment to precision work. Testing and adapting electronic equipment components and division methods for precision short and long range position determination.

(14) Surveying operations along or near the coasts and in the harbours of Liberia of such limited extent as to the impracticable or uneconomical methods of accomplishment by a major vessel; coastal control triangulation and traverses, chart revision surveys, limited surveys for special purposes.

(15) Making smooth projections; checking field observations; plotting smooth hydrographic sheets; inking topographic sheets; preparing descriptive, comprehensive and special reports.

Functions of relief and auxiliary services —geodesy

(1) These cover:

Administrative supervision of:

Field parties engaged in tide and current work along the coasts and inland tidal waters of Liberia and office processing of the resulting data in the various forms required for use by the bureau, other governmental agencies, and the public; research on tides, currents and related phenomena and preparation of special studies for the Army, Navy, Air Force, Coast Guard engineers, and scientists.

(2) Operation of the preliminary tide stations along coasts of Liberia, including the necessary annual servicing and maintenance of bench marks; systematic observations of tides, currents, temperature and density of sea water special tide and current survey for the Army, Coast Guard. and municipal organizations.

(3) Administrative supervision of:

Magnetic observations and seismological stations; and field parties making magnetic seismological surveys; office processing and publication of resulting data in the various forms required for use by the bureau, other governmental agencies and the public; location of earthquakes and analysis of descriptive earthquake motions; preparation of plans and specifications for instruments and equipments and for observatory building; development of industrial equipment.

(4) Operation of magnetic observatories, observation in the field and at observatories for determination of value of the earth's magnetic elements; establishing of magnetic stations for local engineers and surveyors; standardisation of instruments; maintenance of international magnetic standards; operation of seismological stations; maintenance of earthquake information services; surveys of important shocks; processing of information and preparation of reports; vibration observation on engineering structures and measurement of ground vibrations.

(5) Office processing and publication of the data resulting from geodetic surveys of field parties in various forms required for use by the bureau, other governmental agencies and the public; research involving the mathematics of map projection, coordinate grids, the variation of latitude, figure of the earth and improvements in instrument and methods.

(6) The operation and administration of the geodetic field parties of the bureau engaged in: the extension of

precision triangulation, traverse and levelling, base measurements, astronomic observations of latitude, longitude and azimuth; gravity determinations as required for surveying, engineering and research work; operation of the variation of latitude and longitude observatories.

6, (II) (*c*). *Functions—Photogrammetric Engineering division*

These cover:

(1) Planning and supervision of the operation of field parties engaged in topographic and planimetric surveys, revision and correlation of the resulting data, and compilations of topographic maps there from. The compilation of maps from aerial photographs by graphic or stereophotogrammetric methods. Design of photogrammetric equipment.

(2) Operation of all field parties obtaining and using aerial photographs including air photographic missions, photogrammetric field parties, and airport survey parties. (Compilation of topographic and planimetric maps from aerial photographs.)

(3) Graphic compilation; radial plotting for horizontal control breakdown compilation of maps from aerial photographs by graphic method; preparation of mosaics liaison with Division of Charts.

(4) Administrative planning (project planning and correlation of field and office activities); evaluation of surveys and map data; evaluation of new methods and procedures, and recommendations for improvements; preparation of instructions for field and office operations and preparation of flight plans instructions for aerial photography, cost accounting and annual budget estimates.

(5) Stereoscopic mapping: compilation of topographic maps from aerial photographs and photogrammetric field surveys by means of stereoscopic plotting instruments.

(6) Research: research in new methods of photogrammetry; development and design of new photogrammetric instruments and equipment. Maintenance of photogrammetric equipment. Direction of execution of aerial photography, including training of flight personnel.

(7) Photogrammetric field: field offices at which topographic and planimetric maps are compiled graphically or by stereoscopic instruments from aerial photographs, using the results of the photogrammetric field surveys.

(8) Photogrammetric surveys: all photogrammetric surveys in connexion with the production of topographic and planimetric maps, including necessary horizontal and vertical control, field inspection of aerial photographs, and field editing after compilation.

(9) Smooth drafting: smooth drafting of all topographic maps compiled in the photogrammetric field office.

(10) Geographic branch: acquisition, evaluation and classification of all geographic data required for various bureaux activities including the analysis and selection of source material used in aeronautical chart construction; dissemination of technical information concerning geographic activities between governmental agencies and public; coordination of geographic activities between the bureau and other agencies; preparation of exhibits of activities of the bureau for public display; establishment and cataloguing of geographic names.

(11) Nautical charting: registering, verification and final review of hydrographic, wire drag and topographic surveys of the bureau; special investigation and report of all available hydrographic source material prior to field operations; studies for improvement of survey methods; constructing of miscellaneous projects with use of projection ruling machine; construction and revision of nautical charts from original hydrographic, topographic and air photographic surveys of the bureau and other sources; acquisition, examination and evaluation of all available cartographic information from various sources; furnishing critical information for hand correction of nautical charts for issuance; special investigations for furnishing information on cartographic problems to the public.

(12) Aeronautical charting: construction and maintenance of aeronautical charts and publications for civil aviation; critical examination and evaluation of basic source material with preparation of specifications for its use; acquisition and evaluation of complete information concerning aids to air navigation; periodic flight check of aeronautical charts; computation and construction of any and all types of projections; studies and research for improvement of aeronautical charts and for improved methods of air navigation; furnishing cartographic information to other agencies and to the public; cost accounting and preparation of estimates; performance of any and all of the above functions for the Armed Forces; responsibility for liaison between the Cartographic Service and other agencies in matters pertaining to aviation.

(13) Reproduction: reproduction of nautical and aeronautical charts, topographic maps, graphs, diagrams, etc. through the following methods and processes of lithography; engraving on glass negatives and copper; type composition and printing proofs on paper and cellophane for chart construction purposes; glass and film negatives for photo-lithography, photographic colour prints for proofs,bromide enlarging, lantern slides and other photographic processes; process plate-making to provide printing plates on aluminium; proofs of plates in colours on paper and cellulose acetate; blue line prints on mounted paper or vinylite for chart construction; revision to charts and maps on glass negatives and printing plates; quantity production, with numerous colours in close registration, on single or two-colour lithographic off-set processes; cost accounting acquisitioning of supplies, billing for reimbursable work, etc.

(14) Map information: research, procurement, maintenance and dissemination of map and chart coverage required for bureau activities.

(15) Special drafting: compilation and drafting of special maps and charts. Design and preparation of illustrations for articles and bureau publications.

(16) Research analysis: research for base map information used in the compilation of aeronautical charts; selection on assembly of required source material for maintenance and production of aeronautical charts.

(17) Geodetic control data: maintenance of the file of published geodetic control data; distribution of published data.

(18) Geographical names: responsibility for place

names printed on charts and maps published by the bureau, including research.

(19) Cadastral and other special purpose map features.

Auxiliary or relief functions—photogrammetry

These cover:

Collection, processing, compilation, plotting and charting all economic development data including the following functions:

Geomorphological and ecological studies, interpretation and mapping for geology, census wild animal inventory, volumetric studies for mines and highway studies for all special purpose maps.

6. II (*d*). *Functions of the Photography and Reproduction Division*

These cover:

(1) Aerial film development: indexing of aerial photography, making contact, ratio, transformed and rectified prints and diapositives.

(2) Execution of aerial photography for topographic mapping, airport surveys, and for nautical chart revision; supervision of field photographic personnel; responsibility for operating of equipment and quality of photography.

(3) Aero litho section: ingraving and retouching glass negatives; correcting metal printing plates.

(4) Aero litho section 2: Engraving and retouching glass negatives; correcting metal printing plates; special projects.

(5) Research section: investigation and development of processes, instruments, etc.

(6) Planning and layout section: layouts of projects and control for process work; routing of work.

(7) Copper and Machine engraving section: care of all current and historical copper plates; engraving corrections to copper plates; proofs of engraved copper plates for issue and photolithography; machine engraving of soundings, elevations, bottom characteristics or similar features of chart or maps on glass negatives.

(8) Photographic section: precise photography for lithographic reproduction, by the wet and dry plate process, of nautical and aeronautical charts; regular and reversed negatives, positives, line and halftone for colour processes, etc.

(9) Type service section: composition and proof of type on paper and cellophane; lithomat, multilith and type press operation, operation of monotype keyboards and casting machines. Operation of varitype and Coxhead composing machines.

(10) Transfer and process work section: reproduction processes on metal and plastic sheets; proving of charts and maps in black or colour; preparation of plates for revision and printing.

(11) Art work section: all work pertaining to posters, original sketches, re-touching and colouring photographs and lantern slides, engraving certificates, etc.

(12) Presswork section: production of nautical and aeronautical charts, topographic maps, and miscellaneous illustrations, in colours by lithographic offset printing. Operation of Multilith and Davidson presses.

(13) Reproduction of nautical and aeronautical charts, topographical maps, graphs, diagrams, etc. through the following methods and process of lithography: engraving on glass negatives and copper; type composition and printing proofs on paper and cellophane for chart construction purposes; glass and film negatives for photolithography, photographic colour prints for proofs, bromide enlarging, lantern slides and other photographic processes; process plate making to provide printing plate on aluminium; proofs of plates in colours on paper and cellulose acetate; blue-line prints on mounted paper or vinylite for chart construction; revisions to charts and maps on glass negatives or printing plates; quantity production, with numerous colours in close registration, on single and twocolour lithographic offset presses; requisitioning of supplies for reimbursable work, etc.

6.3. The cost of establishing such a type of cartographic office varies according to the size of the country. It should suffice as an index to give examples of estimates made by experts after a detailed study of Liberia.

The consulting services branch of the International Training Centre for Aerial Surveys made one of such studies upon request of the Liberian Government. This study was made by Professor W. Schermerhorn personally. His report is available in bound volumes at the I.T.C. An excerpt from this is attached to the ten-year progress report of the L.C.S. showing the personnel, instruments and office facilities needed together with their costs. The Schermerhorn analysis lists equipment, supplies and personnel for a three-year period at a cost of four hundred and sixty eight thousand ($468,000) dollars of which one hundred and eighty five thousand ($185,000) dollars is for an air-conditioned building, and eighty thousand ($80,000) dollars is for a twin-engined aircraft.

Recently Mr. Albert Nowicki headed a team of USAID technicians which made a further analysis of possibilities of resuscitation and improvement of this service, which is so vital to the economic development of the country. The Nowicki report recommends a unified or centralised mapping bureau which would embrace every type of mapping required for the country. In his detailed organization charts he outlines personnel distribution, grading and production flow for an outfit of 374 persons responsible for survey or data collection and mapping. The personnel are as follows: meteorological surveys—21; hydrological surveys—10; geological surveys—30; mining surveys—14; forestry surveys—26; soils surveys—28; general mapping (in which he includes field surveys, photogrammetry, manuscript engravings and reproduction)—125; records division—11; planning division—5; logistics division—48; library services—6; personnel office—9; archives—2; finance—9; and headquarters—3. As the existing situation in Liberia does not combine soils and forestry surveys in the same department with the other branches, the Nowicki analysis provides for liaison facilities in case the unification cannot be achieved. He outlines a procedure whereby all useful information would be pictorialised on maps at the scales ranging between 1:250,000 and 1:50,000. This programme recommends a building with the space of 53,000 square feet costing $600,000 distributed as follows: meteorology—3,000 square feet; forestry—4,000 sq. ft., water resources—

2,000 sq. ft.; mines—2,000 sq. ft.; geology—4,400 sq. ft.; mapping—21,020 sq. ft.; staff and services—8,160 sq.ft.; department staff—2,640 sq. ft.; department headquarters —80 sq. ft.; soils—3,360 sq. ft.; miscellaneous (stairways, etc.)—2.340 sq. ft. He recommends equipment costing $475,00 and an operations budget of $625,000. Following these pre-requisites Mr. Nowicki and his team expect a properly functioning and balanced Mapping Department capable of supplying printed large scale topographic maps of the whole country and having functional elements responsible for collecting, analysing and translating into mapable and statistical form the requirements for the economic development of the country, which would include geological, water resources, economic minerals and meteorological surveys studies and tests; and cadastral and boundary surveys, mapping and title registration.

7. METHODS AND INSTRUMENTS

It is always necessary that surveys and mapping precede the economic development programme. It is quite obvious, however, that in the new and emerging nations, with no mapping done already and whose rate of development is very rapid, the old classical methods of surveying and mapping are too tedious to complete the over-all mapping in time to precede or even be abreast of the economic planning programme. Extensive use will therefore have to be made of Photogrammetry and of the latest electronic measuring and computing techniques. A centralised mapping office is also recommended so as to minimise the waste due to a multiplicity of mapping services in various agencies.

7 (i). Here we must return to procedures involved in map-making and reproduction. While basic principles remain the same, the type of method applied would have to depend upon the types of instrument available and the training of the personnel on hand. If adequately trained personnel are on hand and there is opportunity for purchasing equipment for speed and accuracy, then the choice would rest with a given range of newly developed instruments and techniques.

The use of photogrammetry with electronic measuring instruments makes the not too old surveyor suddenly appear as an archaic explorer using the perambulator. This difference becomes more apparent when he tries to prevent the application of modern techniques simply out of the arrogance of being the one in charge who cannot understand. Nevertheless, there is always a place for the age-old instruments and methods whenever used in combination with new methods and instruments for greater productivity.

The prime requirement in the selection of instruments and methods must be based upon the criterion that a map must be produced without measurable error. The scale of map required would therefore determine the degree of accuracy of the data and so the type of instruments and methods that would produce the best results in the shortest possible time (or at least within the dead-line).

7 (ii). One scheme for a small-scale topographic mapping of a large territory would entail locating the geographical positions of points at wide intervals by tellurometer or Mann's zenith-camera observations, applying gravimetric compensation. Vertical control could be had by running automatic levels along selected roads and connecting them with micro-barograph readings and by interpolating spot levels run to river surfaces at wide intervals. For aerial triangulation, infra-red vertical aerial photography should be taken at scale 1:70,000 with a fully automatic extra wide angle camera synchronised with Shoran or such other electronic measurements to ground control points, and with a horizon camera, an airborne profile recorder and its accessories, and with airborne geophysical prospecting equipment. Photograph co-ordinate points obtained by aerial triangulation could be adjusted by Yerie block adjustment methods. For very small-scale mapping stereo templets could suffice. Controlled, annotated mosaics could be made from rectified photographs.

For very large-scale mapping, which would be required for layout and construction projects, more precise methods would have to be employed. This would necessitate control provided by aid of precise levelling and horizontal measurement. It would require aerial photography at scale 1:25,000 followed by an accurate aerial triangulation and plotting. There is a wide range of precise instruments on the market. It is recommended that selection of the very best be made for very large-scale mapping. Many instruments and methods described for use in small-scale mapping can be adapted to large-scale mapping. The high speed and accuracy with which survey and mapping can be done by use of Photogrammetry with electronics makes its use indispensable. Moreover, the cost required to complete extensive projects is negligible when compared with the old classical methods.

Contours could be drawn on maps at intervals depending on the scale required and the accuracy of the vertical aerial photography and the vertical and horizontal control. Determination of contour lines could be done either on a projection-type anaglyph or mechanical plotter or on an ordinary stero-meter-mirror-stereoscope depending on the scale and contour interval required.

The several plotted sheets would have to be co-ordinated and projected on some central projection system: probably the Universal Transverse Mercator for small-scale mapping or the Hotine's rectified skew polyconic or such other type of orthomorphic projection for large-scale mapping.

Reproduction and application phases would have to be executed with equal efficiency.

The need for highly trained personnel cannot be over-emphasised. Already trained personnel need specialised or refresher courses. They also need to attend related international scientific conferences and seminars in order to keep up-to-date in their techniques and instruments.

7 (ii) (*A*). Quite a large variety of instruments and methods are in current use. These are displayed *en masse* at related international scientific conferences, notably the Congresses of Photogrammetry, Geodesy and Cartography and of the Federation international des géomètres.

While modern instruments are quicker and easier to operate, they should, however, be adapted to the nature

of the task on hand. As much of the territory of developing countries is still unmapped, these countries need not hesitate to check into a vast storage of disconnected first order work already available, as would have to be done in already developed countries. A complete over-all mapping scheme would often prove more economical.

This procedure would entail establishment of horizontal and vertical control, electronically controlled vertical aerial photography, and then Photogrammetry, photo-interpretation and cartography.

In the case of hydrographic charts, these would require electronic soundings, applied to map with shoreline details. Geological, soils, vegetation and other special purpose maps would require additional ground investigation.

7 (ii) (*B*). *Details of astronomic observations and geodetic positioning*

Using the table of apparent places of fundamental stars, a table of sixty stars as they apparently reach a circle around the 60° altitude, are selected as they would come into transit at the time the observer would be expected to be ready for them. The azimuths of these stars at moment of transit are also computed in advance from the tables to facilitate recognition of the star. Time signals on Station WWV are used to correct chronometer readings which are read with stop watch subtractions to determine the moment of 60° transit in the time of a place with accurately determined lattitude and longitude and so provide a basis for comparison with the moment and altitude when such stars would be at the 60° transit at the point of observation. The average of these results is taken after each observation has been corrected for parallax and refraction as well as deflection of the plumb line, atmospheric interferences and the other eccentricities required to be rectified, depending on the accuracy required. Azimuths from observations on stars are transferred to ground points to determine true azimuth lines for orientation of the block adjustment. The automatic level is handy because it is very cheap, portable and at the same time makes it unnecessary for the observer to devote much time to levelling the instruments. A more precise account of this method has been described by Mr. Zimmerman of the Geodetic Research Institute in Frankfurt-am-Main. Mr. Zimmerman used this method for geodetic control for the topographic map of City Planning in Montserrado County in Liberia.

The Mann's Zenith camera provides a means whereby stars within a six degree radius of the zenith can be measured in two positions 180 degrees apart and with the mean corrected for the change in time. Other normal corrections are applied according to the accuracy required. The measurements between the respective positions of the same stars are done with a micrometer microscope. The advantage of the Mann's zenith camera is that it is portable and provides a means of automatic correspondence of the camera and the chronometer. This method was used by Mr. John O. Boyer of the USC & GS for positioning the shoran reflector stations for the control of the aerial photography of Liberia. The notes and computations are in the archives of the Liberian Cartographic Service.

Other types of quickly established controls

Recently a team under the supervision of Mr. Zarzeski of the Canadian Aero Service Corporation provided control for topographic mapping by photogrammetry of a large section of Nigeria by use of the Dopler system of radar positioning, Kearfott J-4 compass, statoscope and horizon camera. His method is described in the "Canadian Surveyor" of May 1963. This and other methods being used tend to take the acquisition of control data out of the realm of ground survey. Mr. Zarzeski, working in Liberia, made very large-scale topographic maps on which an accurate design and lay-out of a railway was made from Bomi Hills to the new iron ore mines at Mano River. Details of this feat are described in the "Canadian Surveyor". Mr. Percy Tham applied the tellurometer for control by means of trilateration for the railroad project from Bassa to Mt. Nimba in Liberia. The Aero Exploration used the geodimeter with equal success for the large-scale topographic mapping of Monrovia and vicinity for city planning purposes. These were tied into the grid system of the Liberian Cartographic Service which has the entire country co-ordinated on orthomorphic polyconic projection based on Hotines.

In response to bids Fairchild Aerial Surveys has offered to provide control data and make large-scale topographic maps of Liberia at $7.50 per square mile using existing photography. The Aero Service Corporation at the same time submitted a bid in which they described in detail the methods they would use to get horizontal and vertical control for the same topographic mapping project. This includes running automatic levels along existing roads and tying elevation to water level of rivers to be used to provide further points through interpolation. For intermediate points it provides also for use of hypsometer and precise micro-barographs with compensation applied.

In the proposal of the Aero Service Corporation only six weeks would be required for precise levelling. Accuracy of elevations of control points would be ± 1.5 metres. Existing tide gauge data would be used and additional points between precise levels and river profile points will be provided by micro-barographs using the leap-frog method.

The final maps were to be five colour topographic printed sheets at scale 1:200,000 with 10 and 20- metre contours. The total cost of thus mapping the entire country using existing photography and shoran control was proposed at $426,255.00. Bids for this same project have come from all over the world, including Finnmap, Aero-Exploration, Pacific Air Industries and KLM. Some proposed using existing 1:20,000 geographically controlled mosaics or even the 1:125,000 printed sheets for horizontal control of the 1:200,000 finished topographic map.

7 (iii). *Geodesy methods*

Geodesy embraces measurements that would give the true position of points in relation to other points elsewhere

on the face of the earth. This takes into consideration a specific shape of the geoid and so makes it necessary for all points to be reduced theoretically to that surface. The Geoid in use is Hayford's 1910 transformations of Clarke's 1880 spheroid and the international ellipsoid. Observations must therefore contribute to this attainment.

Thus precise elevations of various points make it possible to reduce physical distances between these points to their equivalent on the sea level datum of the geoid. The knowledge of the extent to which the nadir centering is deviated from passing through the centre of the geoid facilitates the correction of observed co-ordinates to true co-ordinates which lie on planes passing through the centre of the geoid. A knowledge of tides and currents enables a more accurate determination of the true mean sea level datum of the geoid. Knowledge of atmospheric conditions at time of observation provides a basis for correcting the errors in the observations due to the effect of these interferences in the line of sight or on the sensitivity of the measuring instruments. A knowledge of the deviations due to the relative motions of heavenly bodies involved in the observation would provide the basis for further correction of the observations.

The observations themselves require the knowledge of positions of these heavenly bodies provided in tables or the knowledge of positions on the earth's surface if these positions are to be extended by triangulation, trilateration or traversing.

Quite an extensive amount of positioning of points on the surface of the earth is attained by direct measurements to and from these known points, the numbers of which would depend on the types of instrument available. Methods in this category embrace automatic distance measurements, sextant fixes and soundings or trigonometric height measurements according as the surface point is below or above the sea. Techniques of achieving this vary according to the instruments on hand. These range from direct physical measurements with tapes, lead lines or barometric readings and dead reckoning on a signalled shore range for limited accuracy to angular or electronic measurements and extensive computations.

Geodesy has been carried out so long by physical ground methods that now it is being largely defined as the technique and process used to achieve the positioning so long as it is carried out beginning with ground angular and distance measuring instruments. The technique and process of determining these positions directly from photographs has been placed under the name of a technique called photogrammetry. The development of electronic means of positioning of points on the photographs takes Photogrammetry even further from this new definition of geodesy. Photogrammetry will therefore be considered as a separate subject in this text. The extent of work involved in determining of positions of primary control points has been so costly and laborious that in many circles today the definition of the technique of geodesy has also been separated from other ground or sea level surveys to determine general topography or hydrography. The determination of points which are not correlated geographically to points elsewhere on the geoid, particularly in isolated cadastral surveys, are therefore sometimes classified under Geodesy.

For the point of effective organization of a national mapping service in emerging nations, however, this text groups all field ground measurements under the jurisdiction of the division of geodesy and all direct measurements in the office from photographs, graph sheets or electronic positioning under the jurisdiction of the division of Photogrammetry, and indeed such has been also the practice in the Liberian Cartographic Service. As final drafting and projection drawing are done in the same office and often by the same personnel, the finishing of the map has been placed under the jurisdiction of the division of Photogrammetry for the same reason that all the field surveys had been placed under the division of geodesy. Both of these divisions combined with the division of photography and reproduction have been classified as covering the entire science of cartography, hence the name of the National Cartographic Service.

7 (iii) (*A*). *Geodesy—instruments*

Under "methods" certain instruments have already been described because of their use in methods recommended in this text. It should be made clear that other methods are also useful and so are the instruments which employ use of their principles. High precision observations must, however, be made at accessible points very far apart.

The description of some of the other types of instruments given now would therefore throw some light on the methods to be applied when using these instruments.

Instruments may be classified into four main categories: first, second, third and fourth order instruments. These instruments have different functions, ranging from angle, distance, height and gravity measurements by direct or indirect measurements. Many instruments combine a number of these types of measurements.

First order instruments are usually bulky but are very necessary in establishing primary control at vast intervals to form adjustment checks of work done by second, third and fourth order instruments. One example of a first order angle-measuring instrument is the Gigas-type high precision theodolite. It facilitates interpolated reading and photographic recording to two-hundredths of a second. It is mainly intended for first order flare-triangulation and the determination of longitude and latitude at Laplace stations. The telescope has three magnifications—40 X, 63 X and 80 X—at which the field of view at 1,000 feet is 20, 13 and 8 feet respectively. The free aperture of objective is $2\frac{1}{2}$ inches and the shortest focussing distance 33 feet. Angular graduations are engraved on glass horizontal and vertical circles 8 and $5\frac{1}{2}$ inches respectively. Plate and control levels are 2 and 1 second per division respectively. Photographs are recorded on standard 35 millimetre films of fifty exposures per roll, and corrected with micro-barographs and thermograph readings.

Targets for accurate sightings would be on a "electric eye" for sighting through haze, if available, or on small light targets at night or heliothropes during the day.

The former, however, provides a method free from personal errors.

Recording chronographs are used, with radio time signals in coordination with the high precision theodolite with recording micrometer and watch when making astronomic observations. These are used in coordination with quartz watches.

Precision gravimeters are used to set up a gravimetric network to determine corrections to the plumb line of precise theodolites and precise levels. These have sensensitive galvano meters for measuring impulses produced by gravity variations to 20 cm/mgal recorded on graph sheets.

Electro-optical distance measuring instruments of the EDM type are suitable for first order trilateration and traversing. These would include Geodimeters, Tellurometers, and Distometers. For measurement of baselines for triangulation nets between accurately determined astronomic stations, fine measurements are made from graduations on 50-metre standardised invar tapes over posts of known elevation with guide pulleys on fractionless ball bearings and tensioned by weights instead of spring balances. Corrections are applied for atmospheric conditions.

For first order levelling some high precision levels of the "Nabon" type provide magnification of 50 diametres with effective aperture of 2.5/16 inches. Also provided are 2 seconds per millimetre division on the plate bubble readable in coincidence. A micrometer with tiltable plane-parallel glass plate, lever transmission and reading drum attached to objective permits reading to 2:10,000 of an inch. When using two surveyors' rods with two $\frac{1}{2}$-centimetre graduations on inner tape, a median accuracy of $+0.3$ millimetre per thousand metres can be obtained. Other near first order levels permit direct reading by above methods to 1/20 millimetre.

There are several types of precision instruments made by different companies applying different principles but giving the same result. Notable among these companies is the Wild company which makes the T.4, T.3 and the Distomat and the N.3 levels.

For first order work it is always recommended that standardised reference markers be available for periodic checking of the instruments calibration.

Second order geodetic instruments

Angular measurements for second order triangulation, traversing and field astronomy are provided by theodolites with magnification of 30 diametres with effective aperture of $1\frac{2}{3}$ inches. Horizontal and vertical glass circles of $3\frac{1}{2}$ and $2\frac{2}{3}$ inches respectively permit direct reading to one second. Compact and weighing 15 lb. in metal container, they are used to increase the density of control points between first order stations and for azimuth determination for checking the orientation of triangulation and traverses. Special accessories to these instruments are traverse equipment, diagonal-eyepiece, eye-piece prism, striding level, circular compass, tubular compass, rucksack and shipping case.

Distances are measured by light electronic distance measuring instruments of the Distomat 50 type. The measuring accuracy is slightly over 2 centimetres for distances from 100 metres to 50 kilometres. Automatic digital reads to 1 centimetre. For long distances it can be used for first order work. Other instruments in this category is the tellurometer and the geodimeter. This type of distance measurement is used for traversing and trilateration. Second order distances can also be obtained from extension of triangulation baselines or chaining of traverses with inner tapes, or subtense bar measurements for short distances.

Second order astronomic positioning may be obtained by use of the Zenith cameras or prismatic astrolabes, using mercurial artificial horizon. Procedures for attaching a 60-degree prism to the objective of an automatic level to improve an astrolabe has been described already, as has the use of the Zenith camera.

Automatic or pendulum levels supply the need for fast second order levelling. Dumpy levels and Wye levels of the old designs are still in use but too bulky compared with the light pendulum levels with rods reading to 1/100 of a foot. Hydrostatic levelling is used to extend levels over vast expanse of water up to 6 miles. The liquid is passed through tubes stretched across the water with graduated ascending glass pipes on each end. Corrections must be applied for gravity, temperature, air pressure and tide. Portable gravimeters with accuracy of 0.01 mgal are used for one of the spot correction values if a gravity net is not already available.

Third order geodetic instruments

These include the so-called builder's type of transits and levels, chaining with steel tapes on level surfaces with plumb bobs. Subtense bar angles are read also for distance determination. Angles are supplied by one-minute transits or tacheometers generally used for cadastral work. Echo-sounding, hydrodists and sextants can be used for third order work in hydrography.

Fourth order geodetic instruments

These include distance measurements, reduction of stadia measurements and vertical angle for plotting by use of polar co-ordinates or by auto-reducing tacheometers or geodetic-range finders like the "Todis" of F. W. Breithaupt and Sohn. The Wild T-12 is a good fourth order angular measuring instrument. Elevations in this category are generally made from reduction of angular measurements.

Plane tables with auto-reducing alidades are used for direct graphical representation. Prisms are used with tape to locate buildings. Brunton compasses are also used for work in this category in areas free from magnetic attractions. In hydrographic surveying lead-line sounding on dead reckoning along a set range would come into this category.

Most of fourth order work is done to fill in details and height or depth contours between control points.

7 (iv). *Photogrammetry*

Photogrammetry is being increasingly used for speedy acquisition of accurate maps. Much has been written in the beginning of this text on the advantages and applicability of Photogrammetry. What needs to be

dealt with now is the elements of the theory, methods and the details and flexibility of photogrammetric instruments available on the market.

7 (iv) (*A*). *Elementary concepts*

Photogrammetry, as the name suggests, is the science of measurement from photograms. Photograms are photographs that are measurable. For photographs to be measurable they must have known elements. If the plane of the plate or film negative were parallel to a photographed flat surface at the moment of exposure with a distortion free lens of good resolution, and known focal length, then the contact print made from such a film or plate would be scaleable like a map. In this case the perspective projection of the flat terrain would be the same as the orthogonal projection. This photograph would be the same as a map of orthogonal projection with scale reduced and it would be a photogram for direct measurement without corrections. Features on these photograms which are of particular interest would then be inked and the rest of the photographic image washed away leaving a planimetric map.

7 (iv) (*B*). *The ideal situation*

If, on the other hand, the plane of the plate or film were perpendicular to a plumb line at the moment of exposure of a hilly terrain through a distortion-free lens, then the position of points on this plate or film would be at the furthest point of a shadow if a pencil of light were drawn from the centre of the lens to a datum plane parallel to the plane of the camera film or plate. This then would be a parallel perspective projection which would not conform to the positions of the same point on an orthogonal projection of the same scale. Since we need maps for direct measurement these perspectives must be transformed into orthogonal projections. There will be no shadow for a sharply defined peak exactly on the nadir point of this particular photograph just described; but peaks of the same elevation would cast a longer shadow the farther away from the nadir in a direction joining the peak point with the perspective centre of the lens. Here the nadir point would be the exact centre of the photograph. If the nadir point on one photograph appeared on another overlapping photograph taken a short distance away under exactly the same conditions described for the first and if this distance between the camera axis of each photograph were known accurately, it would be possible to mark the point where the nadir point of the first photograph should appear on the second had the terrain been flat. The distance between this plotted point and the actual image point on the photograph is actually the length of the shadow cast by this peak point. The distance between the camera axes at the two exposures plus the length of the shadow divided by the height of the perspective centre over the datum plane has the same value as the length of the shadow divided by the height of the peak point above the datum plane. By solving this ratio the height of the peak point may be obtained. The value of the shadow thus obtained is called a photographic parallax. The same procedure should be carried out for the nadir point of the next photograph. This procedure is very simple also for the points lying on the line joining the two nadir points and their respective image points. If the points are not the nadir point we would not have one of the images as an orthogonally projected point for the reference. If the actual ground position of the point were exactly half way between the nadir points of the two axes of the camera lens, then the end of the shadow of the point would be as much off radially on one photograph as on another and the true position found by plotting the four images of the two nadir points and the two images of the new point on two transparent strips—one for the images on each photograph. Then, line-up on the strip the nadir points over their images. Measure, from each primary point along this line joining the points, the given distance between the axes of the camera at each exposure and prick the points which would be the images had there been no height. Slide the image points backward until the pricked points coincide. If the photograph plotted points of the median point between the nadir points should coincide then it would be right to conclude that the photo-point has the same elevation as the datum plane and that the position of its perspective projection on the parallel photo-plate would coincide with the position of a reduction to the same scale of the orthogonal projection of that point. If, on the other hand, this median point is higher than the datum plane then each of the photo points on the transparent strip would cross each other by a distance which if divided by two would furnish a factor (the differential parallax) for computing the height of the point above the datum plane. The Planimetric position of this median point should be pricked half-way between these image points. Again this pricked point would be the same for a perspective projection as for a proportionally reduced orthogonal projection. The true position of other points of same elevation along this line would be proportional from each of the image points as the distance from the nadir point.

Once the above conditions of photography and layout remain the points of the same elevation and same distance radially from the nadir point the correction to each point would be the same with direction varying radially along the line joining these respective points and the nadir point. If transparent sheets were used instead of strips then it would be observed that the pricked points would coincide with the intersection of the lines joining the respective image points and the nadir points. This would also be the case if the heights of each of the points varied with each other above or below the datum plane. Thus, using transparent stable sheets on which are drawn radial lines to the nadir points and adjusting the nadir points as previously described then the pricked points of intersection piercing the large drawing sheet below or traced on a large transparent sheet above can be regarded as the height adjusted positions of these points or a situation in which the perspective projection has been made to conform to the proportionally reduced orthogonal projection. This method is called the radial line height adjustment method. It is a mechanical solution. If slots were made along these radial lines and studs inserted in the points of intersection of the slots the adjustment will have been done automatically and so save the time of juggling the lines involved in the radial line method. This automatic mechanical method is

called the slotted templets method. The Society for Geodetic Research in Frankfurt (Main) has just made an optical instrument for achieving the same result of transformation from perspective projection into orthogonal and automatically printing it on a photographic plate.

In the slotted templets method several long strips with side-laps can be so slotted by pictures, studded, and then tied down to plotted points for positioning of the net and thereby enable a lot of points of control to be pricked on the drawing sheet so as to enable the co-ordinates to be measured on a co-ordinatograph, and recorded for use in further mapping. The points for slotting are selected at critical points which would appear on overlapping and sidelapping photographs.

7 (iv) (*C*). *The actual situation* (measurements made directly on photographs)

We have dealt with the condition that the plane of the camera plate negative is parallel to the datum plane or the axis of the camera perpendicular to the datum plane. Although there are camera mounts, with gymbal axes for keeping the camera level at the moment of exposure by manual or gyroscopic means, there is seldom a case when the ideal camera position is actually achieved. This makes it necessary to apply corrections to the photograph to bring it to a situation in which it should be if the ideal situation had been obtained.

The effect of tilting of the negative plane with respect to the plane of the horizon produces the effect of squeezing together of the images of the ground image points in the negative area on the lower side of the axis of the tilted plane and the horizon plane (passing through the isocenter); with the squeezing effect increasing with the distance away from this axis on the lower side and increasing on the upper side. When the parallel perspective model becomes tilted then the image of the ground that should have had a square shape now has the shape of a trapezoid with the image of the fringe points falling off the negative on the lowerside and with additional details towards the horizon falling on the upper side. The effect of the tilt with respect to the horizon does not cause a displacement of all the images radially from what its true position should be in an orthogonal projection hence the radial-line or slotted templet method will not always be able to accommodate the lateral displacements so caused. Several methods have been evolved to reduce the deviations in the form of vector or rectangular co-ordinates and so enable the values of the tilting to be accurately determined. Measurements of deviations had been made by radial triangulators for vector determination or by parallax bars or stereocomparators for expressing the deviations in the form of rectangular co-ordinates. Adjustments by direct optical methods with stereoscopic projection restitution instruments seem to have superseded the former until the discovery and procurement of the electronic computers to handle the elaborate computations involved in the former methods. If the restitution instruments were based on direct rolling of a ball and socket joint the solution by means of restitution instruments would not involve the necessity for correcting induced errors from having primary and secondary axes in the restitution instruments. Because of these induced errors formulae for resolving the model vary depending on whether or not the primary axis is the tip or tilt or whether the photogoniometer principle is used.

With the use of the Orthophotoscope, the transformation is done by rectifying the pencils of rays in the perspective and so leaving the problem of correcting the image only for the effect of the attitude. This can be done by an orthogonal projection from the inclined plane to the truly parallel plane by applying the horizon camera correction. This correction could also have been applied simultaneously with the transformation in the Orthophotoscope. This transformed image would show us a true sectional map incapable of being seen stereoscopically with the adjoining picture. With the horizon camera or the solar periscope available it would be possible to insert the values into the restitution instruments directly.

The various methods used are selected according to either the accuracy of the known photograph attitude or the number of ground control points available.

Many examples have already been given to illustrate application of some of these methods.

In addition to the above, further corrections have to be made for the effect of the curvature of the earth on each photogram and for the deflection-like angles of the planes of successive photographs due to the curvature of the earth. These are called phi-cracks when measured in reference to the nadir line and are easily determined if the height of the perspective centre and the air base distance are known.

Further methods of adjusting all the errors of several photographs and adjoining strips simultaneously involve either aerial triangulation or by Yerie—ITC—Block—Adjustment.

7 (iv) (*D*). *Instruments*

Instruments used in the above method vary from the ordinary mirror stereoscope on sliding bars in x and y direction used with paper prints and parallax measuring bars with contour tracing pencil to the stereomicrometer of Santoni which has adjustment levers for adjusting the model and plotting planimetry and contours without further computation or correction. In between these types are the orthostereometer, the Zeiss-stereotope and the American Mahan, Ryker, KEK and multiscope plotters and the aero-sketchmasters.

The cumulative errors of the position of observed control points on several forward and lateral models will have to be mathematically readjusted by the method of least squares.

7 (iv) (*E*). *Measurements of intersections of projected images*

In instruments of this type the interior orientation elements of a camera at the moment of exposure are either directly re-constructed or mechanically simulated through cardanic axes and guide rods. Whenever the lens of the instrument is not exactly as that of the taking camera correction aspherical glass plates or mechanical cams are provided.

Provisions are made for rectifying the model by independent and dual motions of the projectors or the reflectors in x, y, z, bx, by, bz for forward, side and vertical rectangular motions respectively or in $\varnothing$, W, and K for pivoting in the direction of flight, around an axis of the direction of flight or around the vertical axis respectively. After adjustment of the model x, y and z, components are read either from direct measurements of these co-ordinates as they appear physically where the pencils of rays intersect, by relays and lever transfers to rectangular-co-ordinates of angular measurements of the pencils of rays or by a mechanical transformation of the parallaxes through a fixed observing stereoscope and guide arms moving the diapositive plates to simulate the respective pencils of rays.

The degree of accuracy with which the orientation and the recording of the x, y, and z components can be made determines grading of the instruments into first and second order categories.

All first order instruments have the means of recording the components by stamping dies or photographically or both. They also have cumulative registers to record continuous values on a flight line and possibilities of reversing the orientation of the diapositive (base in and base out) for extension by aerial triangulation and for anticipation and insertion of corrections due to earth's curvature. Cumulative errors between the known ground values of points in sections of the strip make it possible for adjustment by least squares or by use of the Yerie-ITC block adjustment.

The development of the solar periscope, and the horizon camera, makes it possible to insert correction values for tip, tilt and swing for more accurate and speedy orientation of the model. The development of the electronic distance measuring equipment, the statoscope and more precise barometers and meteorological recording instruments, improved intervalometers and range finders, synchronised with the camera shutter also facilitates increased speed and accuracy and considerably reduces the number of ground control points needed.

First order instruments provide the possibility of simultaneous plotting of planimetry and contours at variable scales through changeable gears and rigid co-ordinate graphs. For speed however the values of a number of adjusted control points recorded from a model are distributed for use in second order plotters. First order instruments also provide for transfer and register of components by electronic computers of digital punch tape or magnetic recording tapes. The programming of the equations for computation must conform to the system and format adaptable to that particular instrument and so requires special training. They also provide for connexion with the profiloscopes for automatic computing of gradients for roads and railways. Among the major makers of the first order instruments are:

1. S.O.M. which makes Poivilliers Type D using the photogoniometer method of measuring the angles of the rays and relaying them in the form of rectangular co-ordinates;

2. Hilger and Watts makes the Thompson plotter which embodies the same principle; that is being speedily improved into first order category;

3. The Zeiss which makes the Stereoplanigraph C-8, based on direct optical measurement of the rays improved by auxiliary telescope following the different rays, and allows for changeable camera cones and for use in oblique photography;

4. The Officine Galileo which makes Santoni Stereocartograph which simulates the projection rays mechanically by use of space rods with a moving diapositive and fixed lens and allows for a greater range of focal length variation;

5. The Wild which makes autograph A-7 which also uses the mechanical simulation of the projection system with a fixed diapositive and moving lens system.

Officine Galileo, Wild and Zeiss are among makers of first order aerial cameras which have possibilities of use with both panchromatic and infra-red films and glass plates. Wild however has taken the lead in super-wide angle cameras which are particularly useful in the tropical regions where there are always low clouds. A-7 has not however been adapted to its $3\frac{1}{2}$-inch focal length for accurate measurement of co-ordinates.

There is a far greater range of second order instruments which cannot all be mentioned here. The simplest is the multiplex which employs the anaglyph principle with the optical projection system and facilitates an arrangement of a number of camera cones on a bridge with the possibility of simulating the curvature formed by the aircraft in its travel along a barometric level together with the tip, tilt and swing of the various camera positions at the moment of exposure. The Nistri multiplan is an improved instrument of this type which permits graduation of the adjustment and recording elements. A blinker system has been developed for the light table to replace the anaglyph on some models.

Practically all manufacturers of surveying and mapping instruments have seen the vast prospects of photogrammetry and are manufacturing various forms of photogrammetric instruments.

Terrestrial photogrammetry

Increasing use is now being made of terrestrial photogrammetry for use in large-scale topographical mapping and particularly in mountainous areas such as Sweden and Switzerland. Its use is recommended in the emerging countries of Africa.

Photo-theodolites are being manufactured by companies that make other photogrammetric instruments and instruments like the Zeiss C-8 are adaptable for use as a restitution instrument.

Instrument manufacturers

It should not be considered that reference here was made in regard to preference of instrument manufacturers as much as to cataloguing main types of designs. There are many manufacturers of all categories of instruments mentioned in this text which were not named. Noteworthy among these is the Kern Company Ltd., Aarau, Switzerland, that manufactures a full range of

first and second order geodetic and photogrammertic instruments.

Photo-interpretation involves applying one's knowledge of the qualities of physical objects which are discerned from the photogram and making further inferences would give a true analysis or description of objects on the ground. This follows restitution of the photo-model so that a true picture representation will be studied. The number of applications of photo-interpretation have already been referred to earlier in this text. Elaborate studies have been made to set up indexes by which photographic features can be translated into these actual ground features they portray or suggest.

Geophysical measuring instruments are always synchronised with the camera shutter so as to position information recorded. These instruments include the airborne magnetometers, scintillometers and all other such instruments that can be so adapted. Because of their association, these sciences are being gradually transferred into the realm of photogrammetry. Electronic distance measuring equipment and solar periscopes synchronised with the camera for positioning of the photographs at the moment of exposure have further expanded the range of photogrammetry. Improvement in the stability of the film base, the sensitivity and range of the emulsions, the resolving power and accuracy of distortion-reducable lenses with correction plate or cams have all helped to make the science of photogrammetry dove-tail into all the other sciences. It should be noted that infra-red photography would make possible photographs which would render a certain terrain better discernable on the photographs while panchromatic photography would make points on others (particularly urban and desert areas) more discernable.

The use of multi-engined aircraft should be encouraged to facilitate greater stability. The size selected should be large enough to accommodate the instruments and the crew. Except for low altitude photography it might be well to have all small scale photography done by charter of the planes from the airlines and so arrange for provisions to be made accordingly when placing the order for the aircraft by these firms.

7 (v). *Graphical presentation and drafting*

This section in the organization phase might well be attached to Photogrammetry because much of the drafting will have been done simultaneously with the plotting. Even the reduction to the proper scale will have been done simultaneously as will have been the scribing on coated plastics. Thus the photogrammetric section would have now only residual plotting or transfer of auto-reducing tacheometer, range finders or plane table notes to actualize the map at points with clouds or excessive forest cover. Much of the work of actualizing of old finished maps could be done much more efficiently by use of new photography in small aircraft using obsolete-type equipment. This equipment could also find use in periodic forest inventories, soil surveys, road cross sectioning and burrow pit measurements. The map projection in UTM or Polyconic or any selected projection should have been plotted before placing the sheet for the details of the stereoplotter.

The extensive computation needed for adjustment of the blocks or the spatial triangulation makes it feasible to have the ground computations of the triangulation, trilateration and astronomic observations done by the same photogrammetic computors. The notes of the cadastral surveyor could be translated from polar to rectangular co-ordinates and areas automatically in these computors, of say, the Stanley-Cintel automatic reading type.

For computation and plotting of field notes, use would have to be made of logarithmic tables or the ordinary computing machines of the hand-cranked or electrically-cranked type. Simple protractors may be used as may rectangular or polar co-ordinatographs or beam compasses if the plotting of spherical or rectangular grids are required. Reductions if not done by photographic projection could be done by pantographs, proportional dividers or by graphical means either lineally or by squares. The method and instrument used would have to depend upon the accuracy required. A complete set of drawing instruments must be always handy.

It would often be necessary to have the lettering and some conventional symbols for the finished drafting, particularly the colour separation sheets for colour printing, done as a separate process.

It would also be necessary to change the scales of various plotted sheets for inclusion in smaller scale maps. This would have to be done by manual reduction with squares, mechanically with precision pantographs or optically with projection cameras or rectifiers.

This branch would be responsible for collection and processing of all statistical data for insertion on the finished map for the benefit of map users. This section would have to carry out considerable amount of computations if it cannot arrange to get other departments to carry out the statistical studies to the point of presentation. Many of the various types of special purpose maps have been named previously in this text. Where conventional symbols are not already standardised for certain presentation special symbols would have to be improvised.

The drawing on stable base must always be insisted upon. The use of thick transparent or coated vinylite and ascetate stable sheets had been employed depending on whether or not opaque or translucent details were required. They had to be transferred to ozalid transparencies before admitting the possibility of a large number of copies by blue print machines as these materials tend to expand under heat without affording the elasticity for returning to its original state. For this reason and for elasticity to normal under-tension the use of Cronar and Estar bases of 7/1000 inch thickness of Kodak and Dupont respectively are finding increasing use for drafting as well as for photography in thinner types. Astralon or Kodatrace would still be useful, depending on the type of work, and so would ordinary tracing papers or linen.

For map lettering and stick-ups of conventional symbols, considerable advances have been made in recent years. The practice of placing these symbols on photographically are beginning to replace the use of manual stick-ups in some cases.

7 (vi). Photography and reproduction after the drafting is finished; it has to be reduced to the desired scale and printed. Because of the similarity in functions between the photography and the photolaboratory work, it is associated in the same organizational unit as the section performing ground and aerial photography and the laboratory work of the aerial photography. The head of this section must be able to execute or supervise all functions listed earlier in the text. He is the most important man in the whole mapping operation, for the initial photography depends on him as does the final printing of the maps. His photographs must meet the specifications to enable them to be converted into maps and his printing must meet conventional standards for maps on sale to the public.

7 (vi) (*A*). *Aerial photography*

A flight plan needs to be made in advance showing parallel flight lines providing for at least 20% side laps. The scale desired by the photogrammetric section would be a factor in this. This scale however would have to be modified to suit the average cloud ceiling and the elevation rounded off to give an even photo-scale when considering the datum plane. Intervals at which the camera shutter would make an exposure for at least 60% over-lap would have to be calculated in advance to be later checked in the aircraft by viewing through a range-finder before insertion into the intervalometer. In the new cameras, the setting is synchronised with the inter-valometer. Films of proper base and emulsions would have to be selected as would the camera according to the type of features for emphasis—panchromatic film for desert regions and infra-red wide angle with distortion calebrated lenses on first order work over tropical vegetation. Large twin engined aircraft of the DC 3 type would have to be used to accommodate the crew and the heavy instruments—Hiran, statoscopes, profile recorders, horizon or solar cameras and geophysical instruments.

For secondary photography, smaller twin engined aircraft would have to be used with less instruments but requiring greater skill in getting correct side-laps (using the prelorus) and correcting for wind-drift.

Required also would be the correct use of filters and knowledge of calibration data, temperature and pressure of aircraft and the simulation of these so that film conditions would be the same at the three critical moments at exposure, during transfer to diapositive and during photogrammetric use, so that the relative positions of the images will have readjusted themselves to their respective places as they were at the moment of exposure.

Photographs would have to be stapled together into a rough mosaic with serial numbers visible and reduced to form the photo index mosaics with still smaller index to show how these sheets fit on over all very small scale maps of the country.

Negatives would have to be rectified and fitted together over plotted positions of points on each photograph and over a rectangular grid and a standard projection of the geographical circles. These would have to be cut and mounted in equal adjoining sizes.

Photographs would have to be enlarged for use in field investigation.

Instruments of efficiency should be used in a air-conditioned photographic laboratory. Large-range efficient rectifiers, and reproduction cameras with vacuum assembly should be available as should electrically operated film developing tanks and proper film and print dryers. Adequate supplies of the proper developing, fixing and hardening chemicals should always be on hand. Equipment for improving the tone of the photographs electronically should also be available.

Low altitude, vertical and oblique photography would have to be flown in certain areas for the following purposes:

(*a*) To fill in gaps covered by clouds in the over-all photography;

(*b*) To provide periodic data for forest growth and inventory and for calculation of borrow pit data in mines and other excavation work;

(*c*) For progress reports on large contracts;

(*d*) For providing interpretation of index types of forests, geological features, and pedalogical and ecological interpretation;

(*e*) For advertisements of the mapping programme as well as for national reports;

(*f*) For reconnaissance.

7 (vi) (*B*). *Terrestrial photography*

Considerable amount of terrestrial photography by use of the improved photo-theodolites would have to be made.

It would be found necessary for the team to carry out considerable work in ordinary landscape photography on request by various government agencies which, if not performed satisfactorily, would antagonise a number of influential persons who might be needed in the budgeting of funds for equipping the National Cartographic Office.

7 (vi) (*C*). *The cartographic photo-laboratory*

Much of the laboratory work, as applied to aerial photography, has already been described.

For the printing of maps, it would be necessary to have very large reproduction cameras of the types produced by Klimsch for copying records and reducing map scales and for preparation of zinc plates or small Kodalith, Estarlith or Cronalith types of negatives for use in offset presses.

Some of the instruments of the photo-laboratory not already mentioned are timers for exposure or developing, proper lighting systems, morse-type contact printers and simple document copying printers of photographic or ozalid types and simple enlargers. A micro-film copying machine would be necessary for reducing records for proper storage.

The preparation of relief models is often attached to the cartographic laboratory.

7 (vi) (*D*). *Offset reproduction*

This section requires a large amount of space.

The reproduction of these maps are done by photo-lithography or photo engraving. After the map has

been properly redrafted after field checked it is reduced to various scales for printing. A contact photographic print of the filmed map is made on sensitised zinc plates which are passed through acid baths that wash away unexposed parts of the zinc plate leaving an image of the map on which the printing ink would adhere and so transfer the image through rubber blankets to the sheet.

For colour prints, only map features with same colour are photographed in the film for exposure on the zinc plates. The same printed sheets are re-inserted for printing from zinc plates carrying different colour features which are applied in turn using different colours of ink after accurate setting of the common borderlines. Printing should be done on stable paper material or on "retrovyl" or such type of elastic material if required for measurement on boats and aircraft where they are likely to be crumpled in use and so lose their scale value.

7 (vii). *Indexing, filing, storing*

7 (vii) (*A*). *Indexing*

This section is second in importance only to the aerial photography.

A proper indexing and cross-filing system must be practised so as to enable everyone concerned to know what is available. The records and available data as well as delicate instruments must be stored in a manner to be within easy reach of users and beyond the influence of destruction or deterioration by fire or climatic conditions.

Negatives are filed by year or month of photography and numerical serial or by projects arranged alphabetically. Map index sheets show flight lines with reference numbers of exposures, scales and specific usefulness.

A picture index for clarity is made by stapling together pictures in a way to present the index numbers and at the same time showing the terrain features. This procedure is usually done as part of the photographic process for finding out in a practical way if there are gaps, improper photography caused by improper side laps, by clouding or by improper orientation. For photo-filing purposes these picture indices are reduced to scales where the numbers can still be visible and the features discernible and are themselves indexed in reference to some grid pattern on the reduced map of the country.

Mosaic and map sheets are generally serialled and indexed by their lower right corner co-ordinates either in rectangular grid or geodraphical co-ordinates. These sheets are themselves indexed in block grid-like arrangement on the general small-scale map of the region or the country.

Field notes in books can be similarly filed or by project-party-chiefs so that these recorders can be easily referred to whenever their illegible writing or intricate system cannot be deciphered.

Cadastral and special purpose sheets are often indexed in some arbitrary numerical arrangement or simply labelled by the names of the owner. Methods vary from town to town as Cadastral work is usually done on a regional basis rather than on a national basis. They can nevertheless be later indexed on the over-all National grid-system by colouring blocks or sections of the blocks which the property map would cover if drawn to the same scale and specifications.

Progress reports showing amount of mapping or photography done at different scales would follow the graphical filing mentioned for special purpose maps.

7 (vii) (*B*). *Storage*

Storage of sheets is better done in steel cabinets with drawers sliding horizontally on rollers in sizes according to dimensions of the sheets. Roneo's "Flushline vertical panfile" arrangements might make the vertical filing method more adaptable to sheets whose map images would not move in the direction other than the cross-section of the material.

Arrangement in the cabinets would have to follow the indexing arrangements. If sheets are to be stored for long periods it would be well to place thin paper foils between each of them so as to prevent them sticking together.

For storage over long periods and for large circulation of available data, records should be micro-filmed and kept in indexed airtight cylinders. These admit the possibility of accurately representing the data and for distribution of enlarged copies.

Obsolete historical maps should be sealed in air-tight indexed tubes or sent to the museum.

Instruments should be stored on sliding shelves according to their sections of use and their expendibility.

Supplies should be stored in a similar manner. Chemicals and photographic paper or negatives should not be stored together.

All storage should be made in dehumidified or air-conditioned chambers and the temperature in storage chambers for sensitised materials should always be below 60° Fahrenheit.

7 (viii). *Training*

The first approach in the realm of training is to devise means of encouraging students with proper preliminary training to be interested in the profession. This is particularly difficult in emerging countries where legal, political and general administrative or liaison-type professions are luring the few candidates with advanced education and where there seems to be a tendency of remunerating the foreigner or foreign trained technician miles above the national without due consideration of qualification.

In addition to proper incentives it would be well to encourage the emphasis on subjects in school clubs which would build up interest in the profession and for others which would build up an educational background that would later simplify understanding of the mathematical bases of the techniques applied in cartography. If these suggestions are adhered to it would not be difficult to get an adequate number of candidates suitable for training.

Training on the job should be done by the standard method "from known to unknown" and with the realisation that "purpose begets interest and interest begets concentration". Ample arrangement should be made

for scholarships in local and foreign universities as well as for frequent attendance at seminars and related international scientific conferences.

Part three

8. DISTRIBUTION, CORRELATION, FINANCING AND CONCLUSION

This part deals with execution of proposals made in the first part of the text for gaining public interest and finance for the over-all mapping project. It covers mainly adaptation and distribution of the planimetric and topographic maps to the users according to their individual requirements. Done satisfactorily it furnishes the basis for justifying more elaborate financing for improvement of the National Cartographic Service. Thus, this part in a way closes the mapping drama on the initial phase; but it also could have the effect of beginning a wider spiral circuit to advanced and better mapping.

8 (i). *Distribution*

Maps are generally sold to the public at prices within their ability to buy them. They are seldom, however, sold in order to cover the expenses involved in their construction. The biggest value to be derived from maps goes to the nation in the form of increased over-all economy due to expansion in natural resources exploration, in agriculture and commerce, in roads, communications and exports, in urbanisation and in the tourist trade. The details of these have been covered in the first part.

It is because of these over-all national benefits that the National Mapping Organisation should be financed by the Federal Government.

The number of copies of a map to be printed for distribution in each instance would depend on the number of possible users within the period that it could be considered current, depending on the speed of development of the particular section of the country. Allowance should be made for the increase in population and would-be users due to the advancement to which the very maps had contributed when they were first printed.

8 (ii). *Correlation*

This phase entails making direct contact with representatives of all elements in the country likely to contribute towards or benefit by the National Mapping Organisation.

8 (ii) (*A*). Thus, the National Legislature should be requested to enact stringent laws for the preservation of geodetic and other types of control monuments, to make provisions against fraudulent reproduction of maps which had cost the Government such a fortune to compile and to provide conditions of recognition which would make it imperative that adequate funding be provided.

8 (ii) (*B*). The cadastral surveyor should be consulted to introduce to him the number of horizontal and vertical reference marks (at his disposal) which either had been established as control for the photography or had been later planted from directions to near-by features of terrain sharply visible on the map or photogram or extensions of these two categories.

8 (ii) (*C*). The soils, forestry, geological, meteorological and geophysical survey and the statistical analysis services could be consulted for ground data of the mapped terrain so as to facilitate the compilation of information for plotting directly on the base maps or to be used as keys or anomalies for photo-interpretations in order to make special purpose maps of all types useful in economic development.

8 (ii) (*D*). The National Geographic Board should be advised on regional systems of naming as well as on regional historical sketches that would facilitate recognition of the ethymological derivation.

8 (ii) (*E*). Special maps should be made to conform with scales and projection of international maps of the world for planometry, topography, vegetation, mineral and tectonics and for climate.

8 (iii). *Funding*

If the preliminary requirements already outlined are carried out and the public is convinced of the usefulness of maps then the problem of funding would not be difficult.

In the majority of cases, however, it is only the layout man in Cadastral work or in building construction or landscaping, drainage or irrigation who would be coming into direct contact with the user. Some means has to be sought, therefore, to get these intermediate users committed to assist in the funding phase.

8 (iii) (*A*). With Governments interested, the question of currency availability in countries having instruments of offering contractual service should be a secondary consideration. In this connexion it should be recognised in developing countries that a very large portion of credit flow and capital reserve in countries rests on their ability to meet commitments for large orders of specific commodities on time and according to standard. This enables the men of commerce to make bargains all over the world and also renders them liable for damages if the disappointment they cause results in considerable losses to others.

It is surprising that countries with absolutely no natural resources or heavy industry can be considered rich and countries which supply them all they need considered as being poor. Until this discrepancy is thoroughly explored it would be within the competence of this text to advise that those countries lacking in currency exchange try to pass some of their commodities to countries which have signed up export quotas or else contact banks or stock exchange centres in the instrument manufacturing country on possibilities of having firms which process the natural resources of the developing countries to underwrite the cost of the machines to be paid for by them as soon as they shall have received the natural produce.

CONCLUSION

It has been the intention in this text not merely to propound methods of preparation and reproduction

of maps but to place emphasis also on the related topics, particularly the all-important one of the need of convincing the public on the uses of maps so as to secure adequate funding in order to enable those who wish to prepare maps to be in a better position to achieve their objective. It also emphasises the need to ensure that the nations make the greatest application of the maps when they shall have been made and so get maximum returns from the financial outlay for the National Cartographic Service.

RECENT SCRIBING DEVELOPMENTS IN MAPMAKING

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Introduction: the development of scale-stable films, good scribable coatings, and reliable scribing instruments has firmly established the scribing process as an important working tool in mapmaking. Since its introduction in the United States, about 1945, the process has continued to make progress. It has been adopted by the Geological Survey and by most other government mapmaking agencies, in all phases of mapmaking, and is also finding favor as an efficient tool in private industry. Experience has shown it results in time savings up to 30 per cent over conventional drafting methods for preparing map copy. Scribing gives sharper, cleaner lines than can be obtained by drafting with pen and ink; new employees are more easily trained to scribe, and mapmaking processes have been simplified.

Scribing publications: many articles have been written which cover scribing rather thoroughly. Foremost among these is the U.S. Government publication "Report on Scribing." Part I of this report describes the process in general terms; part II describes the process in more detail as it is practiced in various government agencies, and part III is a glossary of scribing terms. The agencies that contributed to the interagency report and that have published part II section on their scribing practice are Aeronautical Chart and Information Center, Army Map Service, Forest Service, Tennessee Valley Authority, and Geological Survey. This paper will discuss the Geological Survey report. Because there are numerous publications on the subject, most of you are somewhat familiar with the basic scribing process. However, a brief review of materials, instruments, and techniques currently in use in the Geological Survey may be of interest in clarifying the current development status.

Base materials: various base materials have been used including glass, vinyl, Homalite CR-39 (a clear, hard, almost colorless, thermally set plastic), and the currently used base material, Mylar polyester film. Mylar has natural dimensional stability, great tearing strength and good transparency; it is resistant to both age and heat, nonsoluble, and waterproof. A wide variety of Mylar products are now available from commercial sources and are being used to varying degrees by government mapmakers, as well as by others. The film is obtainable in various thicknesses, but the 0.0075-inch thickness has been selected as being suitable for most scribing operations. With this thickness it has been found that uneven working surface and small particles of dirt under the material do not materially affect the scribing of lines and the control of scribing instruments.

Base material coatings: the various Mylar surfaces now available include: clear Mylar with an ink surface; matte-surface sheets for pencil and ink; rust, yellow, green, white, or clear scribe-coated sheets; and a white scribe-coated sheet with a black undercoating to permit scribing without a light table. Peel coats are available that can be etched and peeled or cut out and peeled. Several kinds of presensitized Mylar are available with a pencil-and-ink or scribing surface. Emulsions include the wash-off type blue, black, and sepia Diazo emulsions, and photographic-contact, reflex, and projection-type emulsions. A clear, or a pencil-and-ink surface Mylar sheet is used for lettering overlays depending on whether a guide image is to be processed on the surface. Rust and yellow scribe-coated sheets are used for compilation and at the map-finishing stages. These colors give sufficient opacity for plate making, so that the color to be used is a matter of personal preference. Yellow, rust, and white scribe-coated sheets are used in the field, the color also depending on the preference of the user. When scribing was first adopted, the Geological Survey coated its own sheets because a suitable commercial product was not available, but now it is possible to purchase sheets already coated. Geological Survey offices are equipped with modern photographic laboratories and it is still considered advantageous to sensitize our own sheets by whirler or wipe-on methods. Originally, for finished scribing the scriber was furnished a coated sheet with a negative image (clear lines with a dark background), but the current practice is to furnish a positive image. Such an image is easier on the eyes when viewed over a light table and many scribers believe it makes scribing easier. Color proofs are made on white scribe-coated Mylar or on white vinyl plastic. Better proofs are obtained on the vinyl sheet if it is grained. The sheets can be grained in a tub grainer using wooden balls and a slurry of pumice powder in water to which a small quantity of trisodium phosphate is added, to give a cleaner background. Grained vinyl sheets may be obtained commercially if graining facilities are not available. Both whirler and wipe-on color-proving methods are used.

Register techniques: to maintain register of the various color-separation plates, the Geological Survey has developed and constructed a register punch which punches two, three, or four $\frac{1}{4}$-inch holes in the margins of the sheet, depending on the size of the sheet. The

[1] The original text of this paper, contributed by the United States of America, appeared as document E/CN.14/CART/63.

punch incorporates a pressure plate which assures that the Mylar film will be perfectly flat before punching. Sheets are secured in correct register by metal or plastic studs inserted in the holes. The register system is used throughout the various phases of the scribing process including the preparation of the pressplate, and is responsible to a great extent for the success of the scribing process. A picture of the punch appears in the Geological Survey "Report on Scribing," part II.

Peel coats for tint areas: Mylar peel-coated sheets are used to prepare woodland, open-water, and urban-tint color-separation plates. Peel-coated sheets are available in two basic types—one with a coating that can be etched and peeled and the other with a coating that is cut and peeled. When the etch coating is used the scribing guide image is processed on the sheet. The image is then etched, after which the sheet is dyed to prevent lines from printing in areas that are not to be peeled, or as an alternative method, unwanted lines can be opaqued. The coating is then peeled from the areas that are to be printed in a tint color. The cut-and-peel coat is a transparent coating which is placed over the scribed image where outlines of areas to be peeled are cut with a swivel knife or other scribing instrument.

Some difficulty has been experienced with small areas of peel coat dropping off in handling. To prevent this when tints are broken up into many small areas and there is a possibility of the peel-coat film separating from the base sheet the sheet is coated after etching and before peeling with a layer of Flopaque or Stay-Flex paint. This seals the edges of the etched lines but does not affect the peeling qualities of the coating. A recent development in peel coats provides a red scribe-coat layer on top of a colorless peel-coat layer on a Mylar base. The scribing image is processed on this coating unless the sheet is used as an overlay. The outlines of the areas to be peeled are then scribed. The scribed outlines are moistened with a solution that is 80 per cent water and 20 per cent Solox, a wood alcohol solvent. The solution penetrates the peel-coat layer permitting the peeling of the coating from the desired areas. Prior to this time (1963) peel coats that could be satisfactorily scribed have not been available.

Etching: some scribe coatings have been developed to the point where they can be etched to produce duplicates of scribe-coated sheets or other drawings with a fidelity that is about as good as the original. This process is used in map-revision work, along with the technique of etching contour numbers as well as red-road-plate information and lettering. A recent development in this field is a light-sensitive scribable Diazo coating on a clear Mylar base. Exposure to the coating is made through the master or scribed plate. The exposed areas bleach or decompose and the unexposed areas become a reddish brown which is actinically opaque. Additional information can then be scribed.

Lettering: marginal and interior lettering for scribed topographic maps is prepared for reproduction in essentially the same way that it was prepared in drafting. Lettering is cut from a stickup film copy and placed in its proper position on a clear or pencil-and-ink surface Mylar overlay. In the Geological Survey lettering is prepared on Intertype Fotosetter photographic line-composing machines. The machine uses the time-proven circulating matrix-assembled-and-distributed principle as is used in line casting machines. In place of the metal pot, a camera is used. The camera operates on a letter-by-letter principle of photographing each character individually. It is operated by means of a mechanical typewriter keyboard. By using two basic fonts and suitable lenses, 15 sizes can be obtained from 4 point to 36 point. The photo-matrix character is a negative, thus its exposure produces a positive; however, by special processing the film can be developed as a negative. Thus, whether a positive or negative is needed or whether copy is required to read from left to right or from right to left, the Fotosetter camera can produce it for emulsion-to-emulsion contact.

From the film, stickup copy is prepared on stripping film which is coated with a wax adhesive. In the past some trouble has been experienced with the stripping and processing qualities of the various films that have been used. However, the film now being used—Dinolith Hi-speed stripping film with wet or dry release (Di-Noc Chemical Arts Inc)—is proving quite satisfactory after undergoing research to improve its deficiencies for use in stick-up work. The film is coated with a wax adhesive (Flexo Wax C, a light cream-colored dull wax purchased from Glyco Products Co.).

Also of interest is the Hadego Photocompositor, a photographic process machine which can produce type copy in sizes from 4 point to 115 point, as well as fractional point sizes. A complete layout can be composed in any size up to 11 inches by 14 inches in a mixture of faces and a variety of sizes, and in multiple lines without stripping. The product of the Hadego can be used for any photomechanical process: right-reading or laterally reversed film positives or negatives can be prepared. The type is lightweight and large enough for easy handling. It is hand set in a composing stick in much the same way as conventional foundry type. The stick is then placed in the line-holder on the Photocompositor where it is photographed.

Instruments: various instruments have been developed by the Geological Survey for use in the scribing process. The current models represent considerable improvement over previous ones. When additional instruments are needed, a thorough evaluation is made of the size, shape, weight, ease of handling, construction costs, and appearance of the existing instruments to determine whether improvements can be made in the design. Changes are incorporated in the new instruments if instrument operation can be improved. Pictures of current models of scribing instruments and scribing accessories are shown in the Geological Survey Manual of Topographic Instructions, in chapter titled "Color-separation Scribing." They include the fineline graver, rigid graver, building graver, swivel graver, sharpeners, electric and mechanical dotter, building and rigid-graver guides, and other miscellaneous scribing accessories.

The swivel graver which scribes two lines at one time uses either needle scribing points or blade-type cutters. Other features of this graver are the ballbearing races which permit smooth action and good instrument control.

This smooth action is necessary for the very thin die coatings that are now available for special types of scribing tasks. Another special feature of this graver is the graver head which is made in two sections. Both head sections and the shaft to which they are attached are grooved, thus, when needle points are once sharpened, space between the points can be varied without disturbing the head alinement because movement of the head sections is controlled by the mating grooves on the head and shaft. Prior to the development of this feature needles had to be resharpened each time the space between the points was varied. This Survey-developed instrument, as well as the Survey building graver and rigid graver, can now be obtained from a commercial source. Another Survey-developed instrument is a swivel graver that can scribe four lines at one time at variable spacings. This instrument incorporates the same features as the standard swivel graver previously described. The modified building graver and building graver guide permit the scribing of row houses at predetermined spacings.

Instrument development: although good basic instruments are now available the search is continuing for new and improved tools and scribing equipment. Instruments that are available from other sources are purchased and evaluated. If preliminary evaluation shows they offer advantages over our own equipment, small quantities are purchased for trial use in our regional mapping centers. For instance, two instruments were accepted as having advantages over Survey-developed instruments. One of these instruments is a spring-loaded rigid graver. Some of our personnel prefer it to the Survey type. With the spring-loaded graver the cutting pressure is controlled by spring action. The other commercial instrument in use is an electric dotter. The dotter is reasonably priced and is efficient, but heats to an uncomfortable operating temperature after about a half hour of continuous use. The Survey-developed dotter can be operated all day without overheating, but it is considerably more expensive. Approximately 15 of the Survey type are in use and 32 of the commercial type.

Considerable effort has been expended on mechanical lettering devices. Two types have been developed and used in reproduction work: A LeRoy type device and a pantograph scriber. More development work is needed on these instruments before they can be used efficiently by the average scriber.

Experiments have been conducted with Rayescent light panels as a replacement for conventional light tables. These panels, about 3/8-inch thick, generate light by electroluminescence. The light output is uniform over the entire surface and intensity can be regulated by varying the voltage or frequency. Green, blue, yellow, and white panels are now being produced. The panels, which can be obtained in various sizes, are quite expensive, and the light intensity is insufficient for some scribers; however, we can assume that as demand increases for this type of light source prices will drop and light intensity will be increased. When these developments materialize, this type of light will no doubt be adopted for light table use.

Symbol templets: templets for scribing the various map symbols have been developed by the Survey and have become a very important factor contributing to the success of the scribing process. Our present cartographic green plastic templet (a few of which have been distributed here together with instructions for use), is the result of considerable research and development. The templet is made by a punch-and-die process. The green color was selected after trial of templets of various colors. It was also found that the plastic templet was preferred to the metal type because of its transparency. We have also had templets made of glass by a process developed by the Corning Glass Works. The advantage of this type of templet is that intricacy of design is no problem. All that is needed to make this templet is a film negative of the desired design. On the debit side, the glass templet is thick and fragile, and therefore requires careful handling and a careful scribing technique.

Points and sharpening techniques: it should be emphasized that extreme care must be used in sharpening scribing points because this too is a very important part of the scribing process. Properly sharpened points make the scribing task easier, and they produce cleaner and sharper scribed lines. Considerable time has been spent determining the proper cutting angles for the points. The Survey has developed an efficient sharpener, which can be obtained commercially, that gives the proper scribing angles and simplifies the time-consuming sharpening task. The sharpener is designed for the Survey-type instruments and some modification may be necessary if it is used to sharpen instruments that vary from the Survey instrument in size and shape. The instrument and the sharpening procedures for the various gravers are illustrated in the Survey publications mentioned. It should be stressed that the sharpening and shape of the point have much to do with the quality and efficiency of scribing. Scribing points have also received their share of attention. Various types have been used: jewel points, blade-type cutters, osmium-tipped points, carboloy points, special steel points with various types of tips, and a variety of shapes and kinds of phonograph needles. Most of our scribing is now done with the Duotone phonograph needle. We also use blades and a few osmium-tipped points of special design for certain scribing tasks. Although the steel phonograph needle requires more frequent sharpening than the osmium, carboloy, or jewel-type points, it is much cheaper and does not require special handling to avoid damage to the point. The more frequent sharpening that is required has not proved to be a handicap because of the efficient sharpener we have developed. The abrasive quality of the scribe coat is a major factor in the need for point sharpening. We have found that a steel point will require sharpening after scribing only 500 inches of line on some coatings whereas on other coatings as much as 2,400 inches of line have been scribed with the same type of point without any noticeable wear. We are therefore careful to select the least abrasive coating we can obtain, if other scribing qualities are acceptable.

Future trends: despite the continued development, the evolution of scribing on plastic has reached a relatively static situation. Coatings will continue to be improved, better plastics may be forthcoming, and techniques will no doubt continue to get better, but the over-all process,

we believe, will remain essentially unchanged for some time to come. Any notable advance in this field will probably be in the direction of practical automation. The extent to which automation will enter the field of scribing at the map-compilation stage, where the product is primarily one of human skill and judgment, may be difficult to contemplate at this time; but we can speculate regarding automation in final color separation which is the physical means of preparing map copy for reproduction. One step in this direction has been the development of an automatic type-placement system through the efforts of the Army Map Service. When fully developed, the system, which is now partially operational at AMS, will eliminate the duplication of locating the feature to which the type pertains. It will eliminate the time required to cut out strip film, the positioning and alinement of the film, and the editorial review and correction of type alinement as well as most of the manual positioning of the final type image.

Conclusion: this brief review of scribing as it is practiced in the Geological Survey covers only the general procedures that are applicable to all mapping phases. Specialized techniques have been used for mapping projects requiring special treatments. Undoubtedly, many other uses for scribing can be envisioned; however, it would be misleading to suggest that scribing offers answers to all cartographic problems. It will be found that, as with any other process, problems will arise that can be solved only by experience. It is certain nevertheless that good results can be obtained, and at less cost than by drafting methods, if scribers use the instruments properly and if the work is planned intelligently.

ANNEX

Rules of procedure[a]

CHAPTER I. REPRESENTATION AND CREDENTIALS

Rule 1

Each State participating in the Conference shall be represented by an accredited representative. If more than one representative is appointed, one of them shall be designated as the head of the delegation. Each delegation may also include such alternate representatives, advisers, and experts as may be required.

Non-invited State Members of the United Nations, the Federal Republic of Germany and the Swiss Confederation may send observers to the Conference.

Rule 2

The credentials of representatives, and the names of alternate representatives, advisers and experts shall be submitted to the Executive Secretary of the Conference if possible not later than twenty-four hours after the opening of the Conference. The credentials shall be issued either by the Head of the State or Government or by the Minister for Foreign Affairs.

Rule 3

The President and the Vice-Presidents of the Conference shall examine the credentials and report upon them to the Conference without delay.

Rule 4

Pending the decision of the Conference upon the report on credentials the representatives, alternate representatives, advisers and experts shall be entitled provisionally to be seated in the Conference.

CHAPTER II. AGENDA

Rule 5

The provisional agenda set forth by the Secretariat[b] and communicated to the Governments invited to the Conference by the Secretary-General of the United Nations shall form the provisional agenda for the Conference. Any representatives of States participating in the Conference may propose any item for inclusion in the agenda.

CHAPTER III. OFFICERS

Rule 6

The Conference shall elect a President, two Vice-Presidents and a Rapporteur from among the representatives of the States participating in the Conference.

Rule 7

The President shall preside over the plenary meetings of the Conference. He shall not vote but may designate another member of his delegation to vote in his place.

Rule 8

If the President is absent from a meeting or any part thereof a Vice-President designated by him shall preside. A Vice-President acting as President shall have the same powers and duties as the President.

CHAPTER IV. SECRETARIAT

Rule 9

The Executive Secretary of the Conference appointed by the Secretary-General of the United Nations shall act in that capacity in all meetings of the Conference. He may appoint a deputy to take his place at any meeting.

Rule 10

The Executive Secretary or his representative may at any meeting make either oral or written statements concerning any question under consideration.

Rule 11

The Executive Secretary shall provide and direct such staff as is required by the Conference. He shall be responsible for making all necessary arrangements for meetings and generally shall perform all other work which the Conference may require.

CHAPTER V. CONDUCT OF BUSINESS

Rule 12

A majority of the members of the Conference shall constitute a quorum.

Rule 13

In addition to exercising the powers conferred upon him elsewhere by these rules, the President shall declare the opening and closing of each plenary meeting of the Conference, shall direct the discussions at such meetings, accord the right to speak, vote, put questions to the vote and announce decisions. He shall rule on points of order and, subject to these rules of procedure, shall have complete control over the proceedings.

Rule 14

The President may, in the course of the discussions, propose to the Conference the closure of the list of speakers or the closure of the debate. He may also propose the suspension or the adjournment of the meetings or the adjournment of the debate on the item under discussion. He may also call a speaker to order if his remarks are not relevant to the matter under discussion.

Rule 15

The President, in the exercise of his function, remains under the authority of the Conference.

Rule 16

During the discussion on any matter a representative may at any time raise a point of order and the point of order shall be immediately decided by the President in accordance with the rules of procedure. A representative may appeal against the ruling of

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[a] The original text appeared as document E/CN.14/CART/76.

[b] In document E/CN.14/CART/1.

the President. The appeal shall be immediately put to the vote and the President's ruling shall stand unless overruled by a majority of representatives present and voting. A representative raising a point of order may not speak on the substance of the matter under discussion.

Rule 17

During the discussion of any matter a representative may move the adjournment of the debate on the item under discussion. Any such motion shall have priority. In addition to the proposer of the motion one representative shall be allowed to speak in favour of, and one representative against the motion.

Rule 18

During the course of the debate, the President may announce the list of speakers and with the consent of the Conference declare the list closed. The President may however accord the right of reply to any member if in his opinion a speech delivered after he has declared the list closed makes this desirable. When the debate on an item is concluded because there are no other speakers, the President shall declare the debate closed. Such closure shall have the same effect as closure by the consent of the Conference.

Rule 19

A representative may at any time move the closure of the debate on the item under discussion, whether or not any other representative has signified his wish to speak. Permission to speak on the closure of the debate shall be accorded only to two speakers opposing the closure, after which the action should be immediately put to the vote.

Rule 20

The Conference may limit the time allowed for each speaker.

Rule 21

Proposals and amendments shall normally be introduced in writing and handed to the Executive Secretary of the Conference who shall circulate copies to the delegations. As a general rule no proposal shall be discussed or put to the vote at any meeting of the Conference unless copies of it have been circulated to all delegations not later than the day preceding the meeting. The President may, however, permit the discussion and consideration of amendments or motions as to procedure even though these amendments or motions have not been circulated or have only been circulated the same day.

Rule 22

A motion may be withdrawn by its proposer at any time before voting on it has commenced, provided that the motion has not been amended. A motion which has thus been withdrawn may be reintroduced by any representative.

Rule 23

When a proposal has been adopted or rejected it may not be considered unless the Conference, by a two-thirds majority of the representatives present and voting, so decides. Permission to speak on the motion to reconsider shall be accorded only to two speakers opposing the motion after which it shall be immediately put to the vote.

Chapter VI. Voting

Rule 24

Each State represented at the Conference shall have one vote and the decisions of the Conference shall be made by a majority of the representatives of States participating in the Conference present and voting.

Rule 25

For the purpose of these rules, the phrase "representatives present and voting" means representatives present and casting an affirmative or negative vote. Representatives who abstain from voting shall be considered not voting.

Rule 26

The Conference shall normally vote by show of hands but any representative may request a roll call. A roll call shall be taken in the English alphabetical order of the names of the delegations at the Conference beginning with the delegation whose name is drawn by lot by the President.

Rule 27

After the President has announced the beginning of the vote, no representative shall interrupt the vote except on a point of order in connexion with the actual conduct of voting. Explanations of their votes by representatives may however be permitted by the President either before or after the voting. The President may limit the time to be allowed for such explanation.

Rule 28

Parts of a proposal shall be voted on separately if a representative requests that the proposal be divided. Those parts of the proposal which have been approved shall then be put to the vote as a whole; if all the operative parts of a proposal have been rejected, the proposal shall be considered rejected as a whole.

Rule 29

When an amendment is moved to a proposal, the amendment shall be voted on first. When two or more amendments are moved to a proposal, the Conference shall first vote on the amendment furthest removed in substance from the original proposal and then on the amendment next furthest removed therefrom, and so on, until all the amendments shall be put to the vote. When, however, the adoption of one amendment necessarily implies the rejection of another amendment, the latter amendment shall not be put to the vote. If one or more amendments are adopted, the amended proposal shall then be voted upon. A motion is considered an amendment to a proposal if it merely adds to, deletes from or revises part of that proposal.

Rule 30

If two or more proposals relate to the same question, the Conference shall unless it decides otherwise vote on the proposals in the order in which they have been submitted. The Conference may after each vote on a proposal, decide whether to vote on the next proposal.

Rule 31

All elections shall be decided by secret ballot unless otherwise decided by the Conference.

Rule 32

If, when one person or one delegation is to be elected, no candidate obtains in the first ballot the majority required, a second ballot shall be taken, which shall be restricted to the two candidates obtaining the largest number of votes. If in the second ballot the votes are equally divided, the President shall decide between the candidates by drawing lots.

In the case of a tie in the first ballot among the candidates obtaining the second largest number of votes, a special ballot shall be held for the purpose of reducing the number of candidates to two. In the case of a tie among three or more candidates obtaining the largest number of votes, a second ballot shall be held; if a tie results among more than two candidates the number shall be reduced to two by lot.

Rule 33

If a vote is equally divided upon matters other than elections, a second vote shall be taken after an adjournment of the meeting for fifteen minutes. If this vote also results in equality, the proposal shall be regarded as rejected.

Chapter VII. Languages

Rule 34

English and French shall be the working languages of the Conference.

Rule 35

Speeches made in either of the working languages shall be interpreted into the other working language.

Rule 36

Any representative may make a speech in a language other than the working languages of the Conference. In this case, he shall himself provide for interpretation into one of the working languages. The interpretation into the other working language by an interpreter of the Secretariat may be based on the interpretation given in the first working language.

Chapter VIII. Records

Rule 37

Summary records of the plenary meetings of the Conference shall be kept by the secretariat in the working languages. They shall be sent as soon as possible to all representatives, who shall inform the secretariat within three working days after the circulation of the summary records of any changes they wish to have made. Any disagreement concerning such changes shall be referred to the President of the Conference for decision.

Chapter IX. Publicity of meetings

Rule 38

The plenary meetings of the Conference and the meetings of its committees shall be held in public unless the body concerned decides that exceptional circumstances require that a particular meeting be held in private.

Chapter X. Committees

Rule 39

The Conference may establish such committees as may be necessary for the performance of its functions and refer to them any question on the agenda for study and report. Committees shall not introduce any item on their own initiative.

Rule 40

Each committee shall elect its own Chairman, Vice-Chairman and Rapporteur.

Rule 41

So far as they are applicable, the rules of procedure of the Conference shall apply to the proceedings of the committees. A committee may dispense with certain language interpretations.

Chapter XI. Participation of States, non members of the Economic Commission for Africa

Rule 42

Observers of any State Member of the United Nations which is not a member or an associate member of the Economic Commission for Africa may participate in the deliberations of the Conference and its committees, without the right to vote. Such observers may, however, submit proposals which may be put to the vote by the request of any member of the Economic Commission for Africa.

Observers of any State Non-Member of the United Nations to which a notice of the holding of the Conference has been sent by the Secretary-General may participate in the deliberations of the Conference and its committees without the right to vote. Such observers may, however, submit proposals which may be put to the vote by the request of any member of the Economic Commission for Africa.

Chapter XII. Specialized agencies, other intergovernmental organizations and non-governmental organizations

Rule 43

Observers of specialized agencies invited to the Conference may participate without the right to vote, in the deliberations of the Conference and its committees, upon the invitation of the President or the Chairman, as the case may be, on questions within the scope of their activities.

Written statements of such specialized agencies shall be distributed by the secretariat to the delegations at the Conference.

Rule 44

Other inter-governmental organizations and international non-governmental organizations attending the Conference may, upon the invitation of the President or the Chairman of a Committee of the Conference, as the case may be, submit written or oral statements to the Conference on subjects for which these organizations have a special competence.

Chapter XIII. Amendments

Rule 45

These rules of procedure may be amended by a decision of the Conference.