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# FOREWORD

The Fourth International Conference on the Peaceful Uses of Atomic Energy, held at Geneva from 6 to 16 September 1971 under the Presidency of Glenn T. Seaborg, was jointly sponsored by the United Nations and the International Atomic Energy Agency. The conference sessions were held at the Palais des Nations. During the same period a Governmental Scientific Exhibition on the theme "Atoms for Development" was displayed at the Palais des Expositions in Geneva.

The Proceedings are published in 15 main volumes, fourteen of which contain all the 514 papers presented at the conference. The papers are printed in English, French, Russian or Spanish, and the abstracts in all four languages; the discussions are in English. The fifteenth volume contains a Subject Index, an Author Index (including discussion contributors), a Paper Number Index, a complete Contents List of all volumes, and a List of Delegations. There are three supplementary volumes containing the discussions in French, Russian and Spanish respectively.

The conference, which attracted more than four thousand participants, observers and journalists, was planned to interest not only scientists and technologists but also public officials, economists and planners. It thus had a somewhat broader scope than the conferences of 1955, 1958 and 1964. The main topics were grouped under the following six headings: nuclear power; nuclear fuels and materials; health, safety and legal aspects; isotopes and irradiation; international and administrative aspects; and selected subjects of particular interest to developing countries.

The fourth Geneva Conference proved again to be an exceptional forum enabling those working throughout the world on the peaceful application of atomic energy to exchange the latest information on the discoveries, projects and problems of both developed and developing nations.

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# SUBJECT INDEX

## COMPILER'S NOTE

The compiler used, as the starting point for this Subject Index, the sets of descriptors chosen by the INIS staff from the INIS Thesaurus. However, the prime aim of INIS indexing is document retrieval, for which several descriptors are normally used in combination. For the present index, therefore, terms have been rearranged, added and omitted in order to obtain a suitable 'keyword' listing. Cross-referencing has been included to aid the user.

An attempt has been made to index in some depth, giving attention to sections in a paper that touched on topics or items not implicit in the title or abstract: the Panels and the discussions have also been indexed.

In general, therefore, the Subject Index contains keywords of a more-or-less narrow subject scope. However, it is possible to search a **broader** concept by:

(i) either consulting the list below or the Topical Agenda on pages 172-175, noting the volume of interest,
*and then*
consulting the relevant contents from among the collected contents lists on pages 3-42 of the present volume to obtain the titles of individual papers;
*and finally*

(ii) looking up associated keywords in the Subject Index to find related references in the other volumes.

## SUMMARY OF VOLUME CONTENTS



## ACKNOWLEDGEMENT


The compiler wishes to express his appreciation of the generous assistance given by the staffs of both the INIS Section and the Computer Section of the IAEA, without which the early appearance of this material would not have been possible.

# SUBJECT INDEX

**Bold numerals refer to volume numbers, other numerals to pages within the volume previously indicated. Both 'see also under . . .' and 'see . . . for . . .' cross-references are indicated by (see . . . ). Some terms have been abbreviated to comply with the computer-program requirement that both main and second-level terms contain only 30 characters. Only lower-case characters are used.**

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# AUTHOR AND TRANSLITERATION INDEXES

# AUTHOR INDEX

This index includes the names of authors of papers and of speakers on Panels or in discussions.
Bold numerals indicate volume numbers; normal upright numerals refer to the first page of a paper, while italic numerals refer to a comment on a Panel or in a discussion.
A Transliteration Index follows on page 147 for authors' names occurring in the Proceedings in Cyrillic.

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# TRANSLITERATION INDEX

Throughout the 15 volumes of these Proceedings, the INIS Transliteration Rules have been used as laid down in IAEA-INIS-10 (Rev. 1) of March 1971. However, where the Cyrillic is a transliterated form, the correct Roman form is given, e.g. Чом, Дь.: Csom, Gy.

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| P/718 | 1.6 | 4 | 25 | R |
| P/720 | 1.11 | 7 | 125 | R |
| P/721 | 1.13 | 7 | 335 | R |
| P/722 | 1.13 | 7 | 263 | R |
| P/723 | 3.3 | 11 | 529 | E |
| P/724 | 5.5 | 1 | 707 | F |
| P/725 | 5 1 | 9 | 367 | F |
| P/727 | 4.5 | 14 | 59 | S |
| P/728 | 4.1 | 12 | 163 | S |
| P/729 | 1.1 | 1 | 273 | S |
| P/730 | 2.1 | 8 | 121 | S |
| P/732 | 1.10 | 6 | 309 | S |
| P/733 | 1.9 | 6 | 199 | S |
| P/734 | 1.5 | 3 | 217 | S |
| P/735 | 1.3 | 2 | 139 | S |
| P/737 | 5.5 | 1 | 721 | E |
| P/738 | 1.7 | 5 | 317 | E |
| P/739 | 4.3 | 13 | 99 | E |
| P/740 | 4.2 | 12 | 265 | E |
| P/742 | 6.1 | 6 | 375 | E |
| P/743 | 5.5 | 1 | 667 | R |
| P/748 | 4.1 | 12 | 179 | E |
| P/749 | withdrawn | | | |
| P/750 | 1.7 | 5 | 37 | R |
| P/752 | 4.3 | 13 | 147 | R |
| P/755 | 6.3 | 12 | 417 | F |
| P/756 | 4.1 | 12 | 33 | S |
| P/757 | 1.1 | 1 | 185 | S |
| P/760 | 1.8 | 6 | 57 | E |
| P/761 | 6.1 | 6 | 425 | E |
| P/762 | 1 12 | 7 | 211 | E |
| P/763 | 1.14 | 7 | 379 | R |
| P/764 | 2.9 | 2 | 589 | E |
| P/766 | 3.2 | 11 | 445 | F |
| P/767 | 3.4 | 3 | 389 | F |
| P/768 | 4.1 | 12 | 3 | E |
| P/769 | 4.5 | 14 | 411 | E |
| P/770 | 5.1 | 9 | 385 | E |
| P/771 | 5.1 | 9 | 303 | E |
| P/772 | 4.1 | 12 | 49 | E |
| P/773 | 5.2 | 9 | 487 | E |
| P/774 | 1.11 | 7 | 41 | R |
| P/776 | 1.10 | 6 | 361 | F |
| P/778 | 1 2 | 1 | 411 | E |
| P/780 | 1 1 | 1 | 225 | E |
| P/781 | 2.1 | 8 | 137 | F |
| P/787 | 1.10 | 6 | 299 | E |
| P/788 | 1.2 | 1 | 477 | S |
| P/790 | 4 5 | 14 | 441 | S |
| P/793 | 6.1 | 6 | 403 | S |
| P/796 | 6.1 | 6 | 433 | S |
| P/797 | 4.5 | 14 | 161 | E |
| P/798 | 1 6 | 4 | 177 | E |
| P/799 | 1.3 | 2 | 215 | R |
| P/800 | 3.2 | 11 | 341 | E |
| P/801 | 6.1 | 6 | 391 | E |
| P/802 | 1.2 | 1 | 395 | E |
| P/803 | 1 6 | 4 | 61 | E |
| P/804 | 4.5 | 14 | 345 | E |
| P/806 | 1.3 | 2 | 59 | E |
| P/809 | 5.2 | 9 | 435 | E |
| P/811 | 1.3 | 2 | 273 | F |
| P/812 | 1.7 | 5 | 213 | F |
| P/813 | 1.14 | 7 | 389 | F |
| P/818 | 1.2 | 1 | 431 | E |
| P/819 | 1.7 | 5 | 101 | E |
| P/820 | 1.11 | 7 | 85 | E |
| P/821 | 2.6 | 4 | 309 | E |
| P/822 | 2.7 | 9 | 215 | E |
| P/823 | 2.10 | 10 | 153 | E |
| P/824 | 3.1 | 11 | 259 | E |
| P/827 | 4.5 | 14 | 73 | E |
| P/828 | 5.1 | 9 | 335 | E |
| P/829 | 4.5 | 14 | 383 | E |
| P/831 | 4.5 | 14 | 91 | E |
| P/833 | 1.7 | 5 | 345 | E |
| P/836 | 1.14 | 7 | 445 | E |
| P/837 | 2.6 | 4 | 433 | E |
| P/838 | 2.10 | 10 | 123 | E |
| P/839 | 3.2 | 11 | 427 | E |
| P/840 | 4.5 | 14 | 29 | E |
| P/841 | 4.6 | 7 | 487 | E |
| P/842 | 5.2 | 9 | 413 | E |
| P/844 | 4.1 | 12 | 189 | R |
| P/848 | 3.1 | 11 | 207 | F |
| P/849 | 1.3 | 2 | 151 | E |
| P/850 | 3.2 | 11 | 285 | E |
| P/851 | 3.1 | 11 | 181 | E |
| P/852 | 1.13 | 7 | 349 | R |

# TOPICAL AGENDA AND PROGRAMME

# TOPICAL AGENDA

## NUCLEAR POWER AND SPECIAL APPLICATIONS

| Agenda Item* | Session* | Volume |
|---|---|---|
| Energy resources and requirements | | |
| 1.1 Survey of world energy demand and resources up to the year 2000 | B.1 | 1 |
| 1.2 Projected role of nuclear energy in meeting future energy needs | G.3 | 1 |
| Current status of nuclear power plants in operation | | |
| 1.3 Performance of nuclear power plants | A.1, A.2, A.3 | 2 |
| 1.4 Techniques for costing nuclear power plants and recent cost trends | A.10 | 2 |
| 1.5 Review of safety aspects of nuclear power plants | A.4, A.5, A.6 | 3 |
| Current and future developments in power reactors | | |
| 1.6 Optimum integration of nuclear power plants in electrical networks as a means of lowering the cost of delivered power; current experience and future developments | B.12 | 4 |
| 1.7 Developments in breeder and advanced converter reactors including long-term development prospects for fission reactor systems | A.7, A.8, A.9 | 5 |

* Throughout the published Proceedings, the papers are grouped by Agenda Item and not by Session. The Agenda Item numbers give an indication of the way the six main subject headings were divided up. The cross-reference provided here to the Session numbers is included only to complete the record of the Conference.

| Agenda Item | Session | Volume |
|---|---|---|
| 1.8 Prospects of small- and medium-power reactors | A. 11 | 6 |
| 1.9 Nuclear energy for desalination and agro-industrial complexes | B. 14 | 6 |
| Advanced and special applications | | |
| 1.10 Utilization of research reactors and their role in stimulating nuclear technology in developing countries | A. 13 | 6 |
| 1.11 Advanced research uses of reactors and accelerators, and applications in energy conversion | A. 17 | 7 |
| 1.12 Applications of nuclear explosions for civil engineering and mineral resources development | G. 4a | 7 |
| 1.13 Special applications of nuclear energy | A. 16 | 7 |
| 1.14 Status and prospects of controlled thermonuclear reactions | G. 4 | 7 |
| NUCLEAR FUELS, CYCLES AND MATERIALS | | |
| Fuels, materials and services | | |
| 2.1 Uranium and thorium resources, supply, demand and costs | B. 5, B. 6 | 8 |
| 2.2 Integrated planning of nuclear industry, anticipated demand for and supply of enriched uranium, plutonium and heavy water, as well as reprocessing services | B. 9 | 4 |
| 2.3 Review of fuel fabrication processes and costs | B. 7 | 8 |
| 2.4 Experience with fuel reprocessing plants; improved techniques for reprocessing | B. 3, B. 4 | 8 |
| 2.5 Developments in isotope enrichment techniques and trends in costs for enrichment services | B. 2 | 9 |
| 2.6 Review of developments in fuel materials technology | B. 13 | 4 |

| Agenda Item | | Session | Volume |
|---|---|---|---|
| Fuel cycles | | | |
| 2.7 | Uranium-plutonium fuel cycle for thermal and fast reactors | B. 10 | 9 |
| 2.8 | Developments in the thorium fuel cycle | B. 11 | 9 |
| 2.9 | Practical aspects of nuclear fuel management for electric power utilities | B. 8 | 2 |
| Radiation effects | | | |
| 2.10 | Effects of radiation on reactor fuels, fuel materials and assemblies | B. 16, B. 17 | 10 |
| 2.11 | Radiation damage to the internals and structural materials of reactors other than fuel assemblies | B. 18 | 10 |
| HEALTH, SAFETY AND LEGAL ASPECTS OF NUCLEAR ENERGY | | | |
| 3.1 | Health physics and radiation protection | C. 1, C. 2 | 11 |
| 3.2 | Review of developments in radioactive waste management | C. 4 | 11 |
| 3.3 | Environmental effects and public acceptance | G. 6, C. 7 | 11 |
| 3.4 | Legislative, insurance and regulatory aspects | C. 3 | 3 |
| APPLICATIONS OF ISOTOPES AND RADIATION | | | |
| Applications in food and agriculture | | | |
| 4.1 | Nuclear methods of increasing food production | A. 12, G. 7 | 12 |
| 4.2 | Nuclear methods of reducing food losses | B. 15 | 12 |
| Applications in the life sciences | | | |
| 4.3 | Medical applications: techniques and use in diagnosis, therapy and research, including dosimetric aspects | C. 9, C. 10 | 13 |
| 4.4 | Radiation biology: studies of cell function, radiation microbiology and biosphere resources | B. 19 | 13 |

| Agenda Item | Session | Volume |
|---|---|---|
| Use in applied sciences and technology | | |
| 4.5 Industry: study, investigation and development of resources | C.11, C.12, C.15 | 14 |
| 4.6 Production and application of transuranium and super-heavy isotopes | C.6 | 7 |
| INTERNATIONAL AND ADMINISTRATIVE ASPECTS OF NUCLEAR ENERGY | | |
| Safeguards | | |
| 5.1 Safeguards systems analysis and safeguards objectives | G.5 | 9 |
| 5.2 Safeguards techniques and instrumentation | C.5 | 9 |
| Organizational and co-operative aspects | | |
| 5.4 Organization of national atomic energy commissions and their relationship with other bodies and institutions | A.15 | 1 |
| 5.5 International co-operation in nuclear projects and exchange of information | G.8, A.14 | 1 |
| ASPECTS OF NUCLEAR TECHNOLOGY OF PARTICULAR INTEREST FOR DEVELOPING COUNTRIES | | |
| 6.1 Impact of nuclear technology in developing countries | G.9 | 6 |
| 6.3 Education and training of scientists and technicians; public information | C.13 | 12 |

| | | *General sessions – G* | | *Technical sessions – A* | |
|---|---|---|---|---|---|
| Monday 6th Sep. | a.m. | G. 1 | Opening | | |
| | p.m. | G. 2 | Special talks | | |
| Tuesday 7th Sep. | a.m. | G. 3 | Projected role of nuclear energy in meeting future energy needs (1.2) | A. 1 | Performance of nuclear power plants (1.3) |
| | p.m. | | | A. 2 | continuation (1.3) |
| Wednesday 8th Sep. | a.m. | G. 4 | Status and prospects of controlled thermonuclear reactions (1.14)<br>Applications of nuclear explosions for civil engineering and mineral resources development (1.12) | A. 3<br>A. 4 | continuation (1.3)<br>Review of safety aspects of nuclear power plants (1.5) |
| | p.m. | | | A. 5 | continuation (1.5) |
| Thursday 9th Sep. | a.m. | G. 5 | Safeguards systems analysis and safeguards objectives (5.1) | A. 6 | continuation (1.5) |
| | p.m. | | | A. 7 | Developments in breeder and advanced converter reactors including long-term development prospects for fission reactor systems (1.7) |
| Friday 10th Sep. | a.m. | G. 6 | Environment effects and public acceptance (3.3) | A. 8 | continuation (1.7) |
| | p.m. | | | A. 9 | continuation (1.7) |
| Monday 13th Sep. | a.m. | G. 7 | Nuclear methods of increasing food production (4.1) | A. 10<br>A. 11 | Techniques for costing nuclear power plants and recent cost trends (1.4)<br>Prospects of small- and medium-power reactors (1.8) |
| | p.m. | | | A. 12<br>A. 13 | continuation (4.1)<br>Utilization of research reactors and their role in stimulating nuclear technology in developing countries (1.10) |
| Tuesday 14th Sep. | a.m. | G. 8 | International cooperation in nuclear projects and exchange of information (5.5) | | |
| | p.m. | | | A. 14<br>A. 15 | continuation (5.5)<br>Organization of national atomic energy commissions and their relationship with other bodies and institutions (5.4) |
| Wednesday 15th Sep. | a.m. | G. 9 | Impact of nuclear technology in developing countries (6.1) | | |
| | p.m. | | | A. 16 | Special applications of nuclear energy (1.13) |
| Thursday 16th Sep. | a.m. | | | A. 17 | Advanced research uses of reactors and accelerators, and applications in energy conversion (1.11) |
| | p.m. | G. 10 | Summing up and closing | | |

NOTE: *Numbers in brackets indicate the Agenda Items.*

| *Technical sessions – B* | | *Technical sessions – C* | |
|---|---|---|---|
| | | C. 1 | Health physics and radiation protection (3.1) |
| B. 1 | Survey of world energy demand and resources up to the year 2000 (1.1) | C. 2 | continuation (3.1) |
| | | C. 3 | Legislative, insurance and regulatory aspects (3.4) |
| B. 2 | Developments in isotope enrichment techniques and trends in costs for enrichment services (2.5) | | |
| B. 3 | Experience with fuel reprocessing plants; improved techniques for reprocessing (2.4) | | |
| B. 4 | continuation (2.4) | C. 4 | Review of developments in radioactive waste management (3.2) |
| B. 5 | Uranium and thorium resources, supply, demand and costs (2.1) | | |
| B. 6 | continuation (2.1) | | |
| B. 7 | Review of fuel fabrication processes and costs (2.3) | | |
| B. 8 | Practical aspects of nuclear fuel management for electric power utilities (2.9) | C. 5 | Safeguards techniques and instrumentation (5.2) |
| B. 9 | Integrated planning of nuclear industry; anticipated demand for and supply of enriched uranium, plutonium and heavy water, as well as reprocessing services (2.2) | C. 6 | Production and application of transuranium and super-heavy isotopes (4.6) |
| B. 10 | Uranium-plutonium fuel cycle for thermal and fast-reactors (2.7) | | |
| B. 11 | Developments in the thorium fuel cycle (2.8) | | |
| B. 12 | Optimum integration of nuclear power plants in electrical networks as a means of lowering the cost of delivered power; current experience and future developments (1.6) | C. 7 | continuation (3.3) |
| | | C. 8 | Panel on Ecological Aspects and Public Understanding of Nuclear Power |
| B. 13 | Review of developments in fuel materials technology (2.6) | | |
| B. 14 | Nuclear energy for desalination and agro-industrial complexes (1.9) | C. 9 | Medical applications: techniques and use in diagnosis, therapy and research, including dosimetric aspects (4.3) |
| B. 15 | Nuclear methods of reducing food losses (4.2) | C. 10 | continuation (4.3) |
| B. 16 | Effects of radiation on reactor fuels, fuel materials and assemblies (2.10) | C. 11 | Industry. study, investigation and development of resources (4.5) |
| B. 17 | continuation (2.10) | C. 12 | continuation (4.5) |
| B. 18 | Radiation damage to the internals and structural materials of reactors other than fuel assemblies (2.11) | C. 13 | Education and training of scientists and technicians; public information (6.3) |
| | | C. 14 | Panel on Introduction of Nuclear Power into Developing Countries |
| B. 19 | Radiation biology; studies of cell function, radiation microbiology and biosphere resources (4.4) | C. 15 | continuation (4.5) |

# CORRIGENDA TO VOLUMES 1 TO 14

**VOL. 1** **Page 387**, Title of Table III:
*For* PROTECTION *read* PROJECTION

**VOL. 2** **Pages 69 and 70**, figures:
The figure above the Fig.5 caption should be *interchanged* with that above the Fig.6 caption.
(The captions are correctly placed.)

**VOL. 4** **Page 215**, caption to Fig.C
The caption should read as follows:
FIG.C. Flowsheet of a PWR plant with integrated steam storage:
1. reactor; 2. pressurizer; 3. steam generator, 4. main turbine; 5. moisture separator, 6. reheater, 7. main condenser; 8. feed water tank; 9. feed water heater, 10a, b, c. steam lines for heating main accumulators; 11. live steam line for loading superheat accumulator; 12a, b, c. main accumulators; 13. superheat accumulator; 14a, b, c. steam supply lines, 15a, b. superheaters; 16a, b, c. storage turbines, 17a, b, c. condensers of storage turbines; 18. condensate tank; 19. condensate return line; 20a, b, c. condensate lines; 21. live steam line to storage turbines when acting as spare for main turbine.

**VOL. 6** **Page 273**, 3rd paragraph, line 2, first word:
*For* areas *read* acres

**Pages 433-441**, right-hand page running heads:
*For* A/CONF.49/P/798 *read* A/CONF.49/P/796

**VOL. 8** **Page 180**, last contribution and footnote.
In both cases, BRINCK's initials should be J.W.

**Page 362**, Figure 4, column 'STREAM 65':
*For* 3.7 *read* 37

**Page 366**, Reference [11]:
This should read:
[11] BRESCHET, C., MIQUEL, P., "Improvement of the procedure utilised at Marcoule in order to treat highly irradiated fuels (Example of utilisation of complexing and redox agents in a solvent extraction process)", Int. Conf. Solvent Extraction (Proc. Conf. The Hague, April 1971) (in press).

**VOL.11** **Page 279**, 3rd line of contribution by P. BEAU:
*For* on page, *read* on page 103

**Page 281**, 2nd line of M. DELPLA's final contribution
*For* If land had to be given back *read* If land was for sale

**Page 471**, 12th line from bottom:
*For* solification *read* solidification

**Page 471**, 10th line from bottom:
*For* medium-size *read* major

**VOL.12** **Page 367**, 8th line from bottom.
*For* $^{54}$M *read* $^{54}$Mn

**Page 368**, line 7:
*For* (0.5 $MKH_2PO_4$) *read* (0 5M $KH_2PO_4$)

**VOL.13** **Page 353**, first contribution by V. PECORINI:
*For* $^{113}$I *read* $^{113}$In

**VOL.14** **Page 31**, 5th line from bottom.
*For* $^{88}$Yb *read* $^{88}$Y