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Role of Desalting Technology in Meeting Kuwait's Fresh Water N e e d s

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Role of Desalting Technology in Meeting Kuwait's Fresh Water Needs

by

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ABSTRACT

Kuwait is located in a coastal desert area, where the summer season is considered harsh and the water resources are limited to few shallow wells, deep ground water fields and sea water.

In the old days, people supplemented their water needs by shipping potable water from Shat Al-Arab river, in Iraq.

Following the flow of oil and the progressive increase in water demand, Kuwait relied heavily on the exploitation of underground water and on the desalination of sea water for survival.

At present, ground water, of brackish and of reasonable salinity, is exploited from different fields, the fresh being limited in quantities.

The demand for demineralized water is covered by distillation plants of multi-stage cross tube flash type as part of dual purpose system.

Over the years, Kuwait gained long experience in sea water desalination ranged from the operation of 454.5 cubic meters per day (100,000 imperial gallons per day) submerged tube evaporators, to the design of the latest evaporators of 27273 m^3/day (6 million imperial gallons per day) multi-stage flash type, now under

construction. Experience in other desalination methods such as reverse osmosis, electrodialysis and solar stills has also been gained.

Potable water is attained by blending certain percentage of brackish water with the product distillate. The blended water is chemically treated for health purposes.

Being in an arid zone, Kuwait is regarded as a good example of a country which has been able to cope well with the serious lack of natural water by turning to the desalination of sea water.

1. Introduction

Many areas of the world are blessed with sufficient rainfall or enough surface or subsurface water to support the year round or seasonal growth of enough food for the populace as well as for potable use. In the arid and semi arid regions of the world there is not sufficient fresh water available either for drinking or for agriculture. In these geographical areas, where Kuwait* is located, it is imperative that some form of desalting be employed to meet the needs of the population.

Kuwait is relatively small state in both area and population. The total area is about 15,000 sq. km. and it has a population slightly exceeding one million.

Being in an arid zone Kuwait had suffered the serious deficiency of natural fresh water resources. There are no lakes or rivers, and the average annual rainfall is not more than five inches.

Kuwait is considered one of the hottest and driest places in the world. The maximum shade temperature recorded is 50°C (112°F) and maximum sun radiation can be as high as 84°C (183°F).

Prior to 1925, the people relied mainly on seasonal rain and on shallow wells which produced limited supplies of low salinity water. In the years between 1925 to 1950 the water supply was supplemented by shipping potable water from Shat Al-Arab river in Iraq, a distance of approximately 100 miles. The water was transported by

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* All locations referred to in subsequent paragraphs are to be found in figure I.

Dhows which at times were subject to very bad weather conditions including gales and dust storms. Consequently the quality as well as the quantity of the water were unreliable.

The existing water sources in Kuwait are limited to brackish ground water, fresh ground water and distillation of sea water.

2. Brackish Ground Water

Kuwait employs what is known as a dual distribution system whereby fresh and brackish water are piped separately. The two systems run parallel to each other.

The brackish water is used for agriculture purposes, domestic uses (other than drinking) and for augumenting the highly pure distilled water by 10 to 15% in order to bring the total dissolved solids level in the blended water to about 500 ppm.

Apart from minor local wells, which are scattered over many parts of Kuwait, there are three major fields of underground brackish water. These are:

2-a-1 Sulaibieh Field

The field can produce as much as 20 million imperial gallons per day (MIGPD). The present salinity of this field water is between 4000 and 5000 mg/l. It has been recommended not to increase the production from Sulaibieh field in order not to decrease the present reserve and increase the water salinity.

2-a-2 Abdulyah Field

The field of Abdulyah which has been exploited by the Kuwait Oil Company is reported to have a capacity of 8 MIGPD.

2-a-3 Al Shegayah Field

This field is located west of Kuwait and it covers a wide area. The productivity of the field has been estimated to be 63 MIGPD. Its salinity is between 2500 to 6000 mg/l.

2-b Fresh Ground Water

In 1960 ground water with reasonable salinity, 800-1000 mg/l, was discovered in Rawdatain, 104 km north of Kuwait city. In 1964,

the reserve of the field was estimated to last for 20 years at a production rate of 4.0 MIGPD. The production at Umm Al Aish started in 1965. The salinity ranges between 350-1900 mg/l with an average salinity of 1300 mg/l. It was estimated that the new field could be pumped at an average rate of 2.0 MIGPD for 20 years.

3. Sea Water Desalination

3-a Available Capacities:

The main supply of drinking water is provided by three major distillation sites. A fourth site is presently under construction. The capacity of distillation and power plants at each site is as follows:

Site	Water (MIGPD)	Electricity (MW)
Shuwaikh	18	160 Steam + 204 Gas Turbine
Shuaiba North	14	350 + 50 Gas Turbine
Shuaiba South	30	804
Doha	42 *	1050*
Total	104	2618

All of these distillation plants are of the multi-stage cross tube flash type (MSF) and form part of the dual purpose complexes. Development of the installed capacity is shown in figure II.

Kuwait's experience in sea water desalination back to as early as 1950 when Kuwait Oil Company commissioned a submerged tube type desalination plant. Later, in 1953, the then Department of Electricity and Water which was later upgraded to the Ministry of Electricity and Water, commissioned its own first desalting plant comprising 10 triple-effect submerged tube evaporators each having a capacity of 100,000 IGPD, followed in 1954 by a similar one having the same capacity. After

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* There are under construction 3 units of M.S.F. plants each 6 MIGPD. The rest which are of the same size and design have just been contracted.

various considerations and economical assessments of both submerged-tube and flash type, the Ministry turned to flash evaporation and in 1958, ordered the first 4 stage flash type evaporators. During 1960 the breakthrough in Multi-Stage Flash technology occurred and the first plant of 19 stages flash type evaporator of one MIGPD capacity was commissioned. Since then Kuwait has been using the multi-stage flash evaporators of cross-tube design, low temperature polyphosphate dosed for scale control. The maximum unit capacity in operation is 5 MIGPD but the units under construction are of 6 MIGPD distillate capacity each.

3-b Method of Utilization

All Kuwait's distillation plants are part of dual purpose system wherein the plants are coupled with conventional steam power turbines. This provides a more efficient utilization of steam and of sea water intake and disposal installations.

Part of the reject brine is processed in a plant adjacent to Shuwaikh Power Station for the production of common salt, chlorine, hydrogen, hydrochloric acid, caustic soda and other byproducts, thus forming what is known as a multi purpose complex.

4. Chemical Treatment

4-a Marine Fouling Control

It is well known that marine organizms are present in almost all sea water. Marine fouling can be prevented in a number of ways; in Kuwait chlorine is continuously injected into the suction end of the sea water pumps at the forebay.

The chlorine is injected at such a rate as to give a residual of about 0.5 ppm of free dissolved chlorine, the total injection averages 2 ppm. This method has been quite successful in controlling marine fouling.

4-b Chemical Treatment of Potable Water

Most of the installed distillation plants produce distilled water of a high purity i.e. 1-5 ppm as total dissolved solids. The gross production of distilled water during 1960-1976 is shown in figure III.

Make-up and service water for power station are taken from the distillate product. The remainder is pumped to the distribution water

reservoirs after dosing with caustic soda to adjust the pH to about 7-8. At the reservoirs, this low-salinity water is blended with a high-salinity brackish water (3500-4000 ppm) at a rate of 10% to 15%, in order to bring the minerals level to a palatable and healthy level of 500 ppm. Chlorination and fluoridation are carried out at the chemical dosing plants for health purposes. Figures IV to VIII indicate the development in fresh water production and consumption.

5. Cost of desalted water

Recent calculations and analyses of capital, operation, maintenance and over-head costs of a dual purpose water/power complex in Kuwait for the year 73-74 indicated the values listed below.

Cost of Power generation 1.2-2.6 fils*/kwh

Cost of Water production 365-560 fils/1000 I.G.

The cost evaluation was based on a 15 year depreciation and 5% interest rate per annum. However the costs will increase considerably if the prevalent commercial cost of energy and land are used and the invested capital appraised to reflect current prices.

6. Conclusion

Kuwait has set through its long and successful experience with sea water desalination, an example which can be followed by many other countries facing similar water shortage problems.

It has shown the world that with forward thinking and planning the non availability of natural fresh water supply can be overcome by turning to the sea.

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* 1 Kuwaiti Dinar = 1000 Fils = 3.40 U.S. Dollars, at the time of writing this paper.

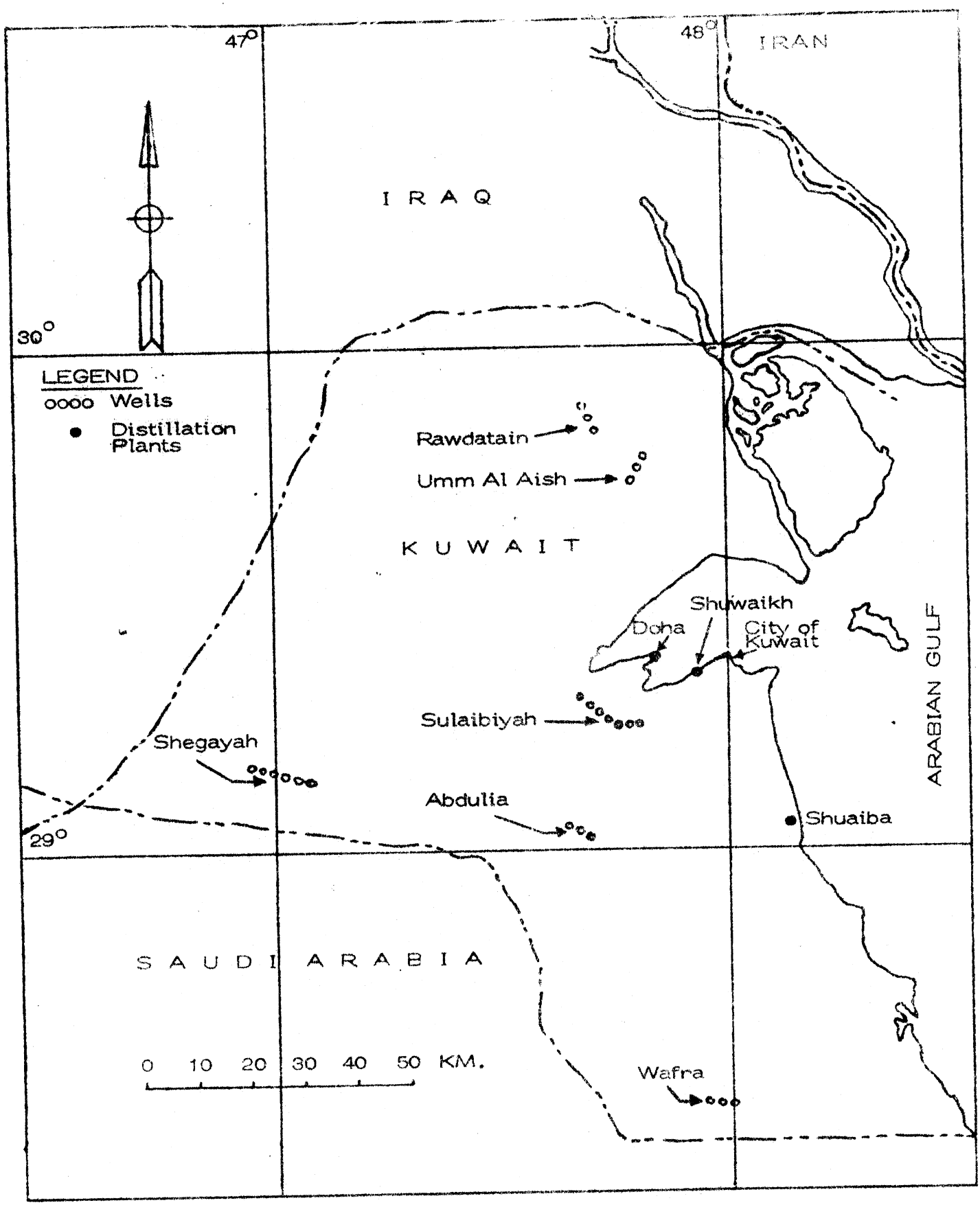
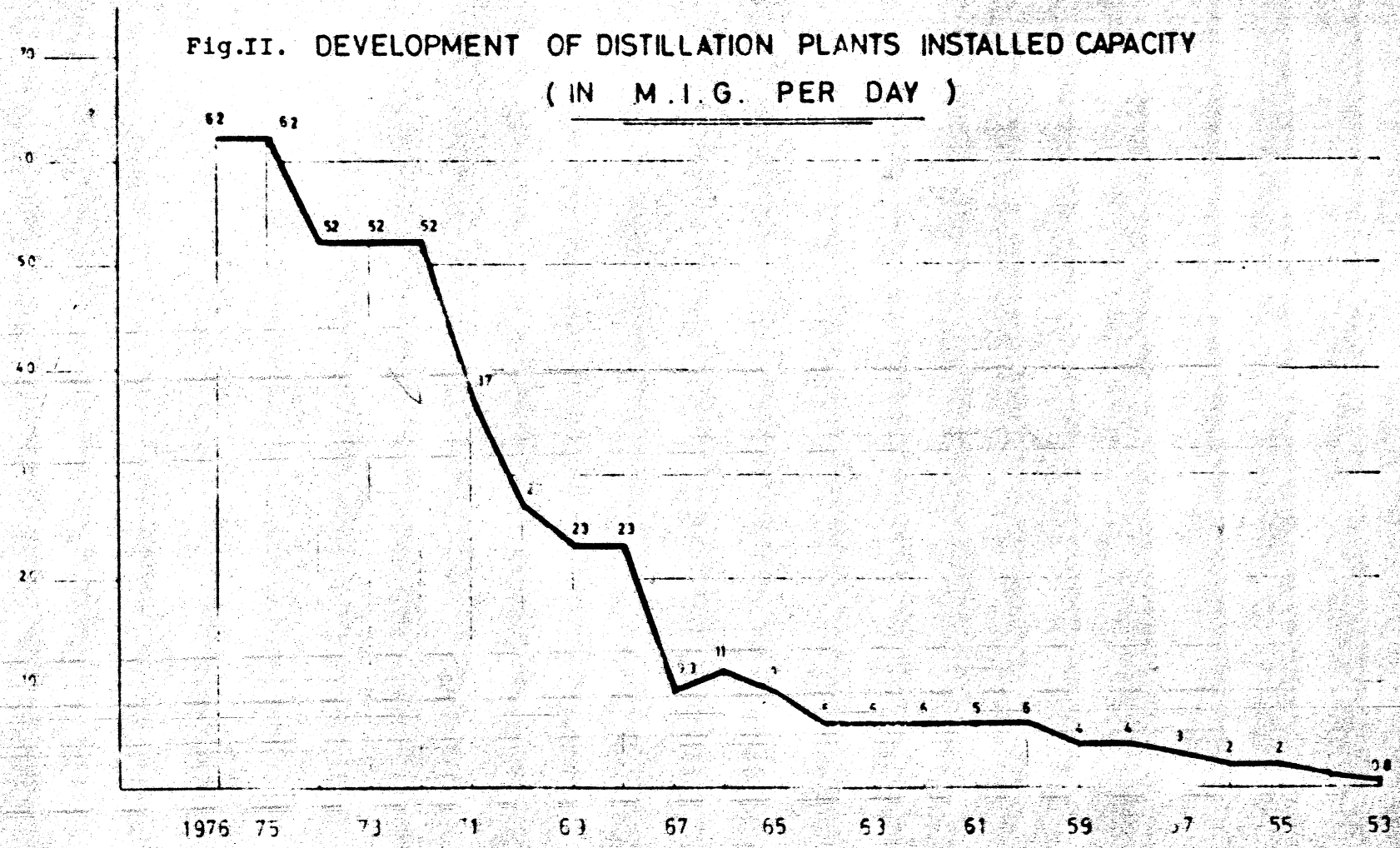


Figure 1. EXISTING KUWAIT WATER SUPPLIES

تطور القدرة المركبة لمحطات التقطير - بليون جالون ابراطوري يومياً

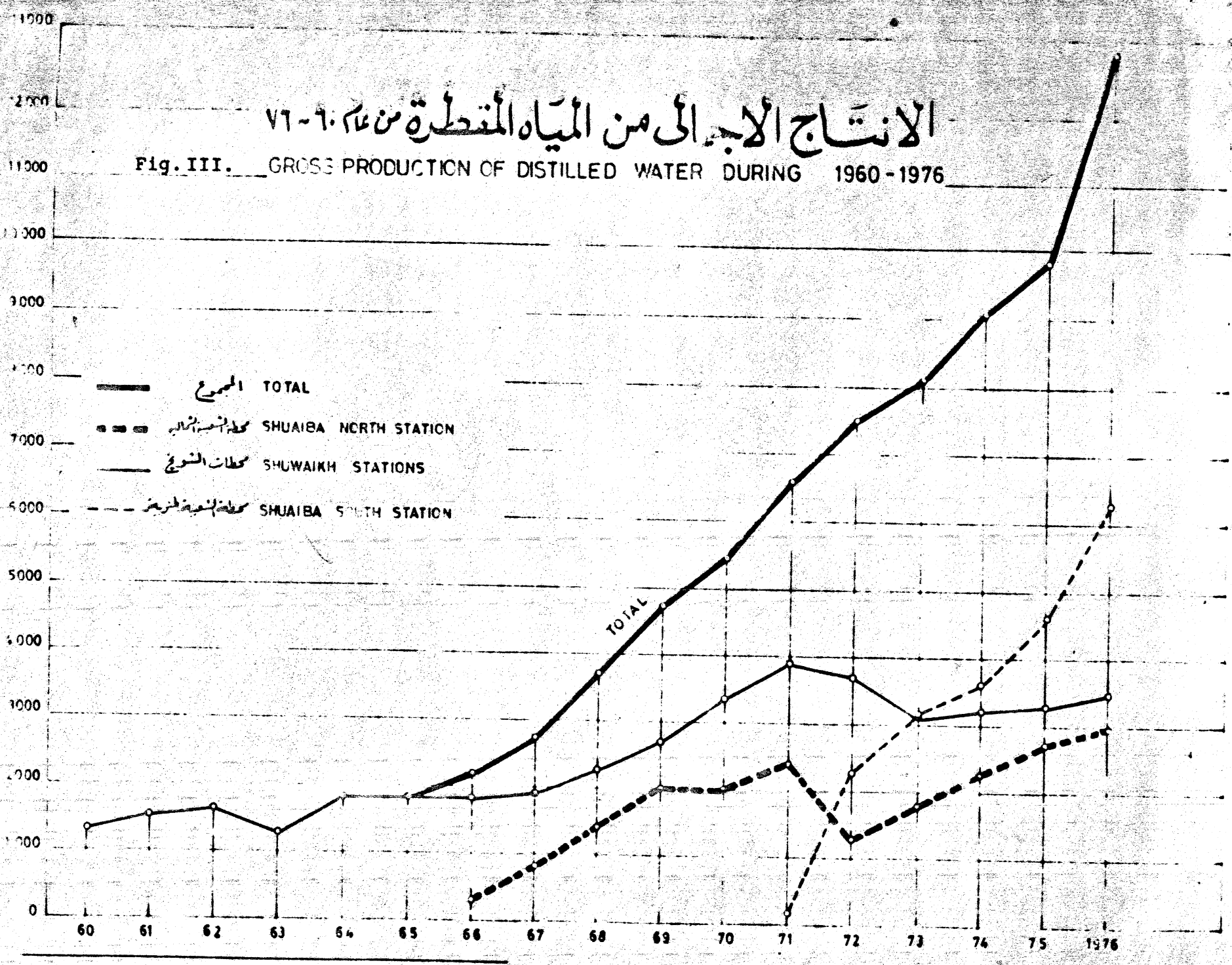
Fig.II. DEVELOPMENT OF DISTILLATION PLANTS INSTALLED CAPACITY
(IN M.I.G. PER DAY)



This figure has been obtained from the Statistical Year Book of the Ministry of Electricity and Water for the year 1977.

الانتاج الاجمالي من المياه المقطرة من عام ٦٠-٧٦

Fig. III. GROSS PRODUCTION OF DISTILLED WATER DURING 1960 - 1976



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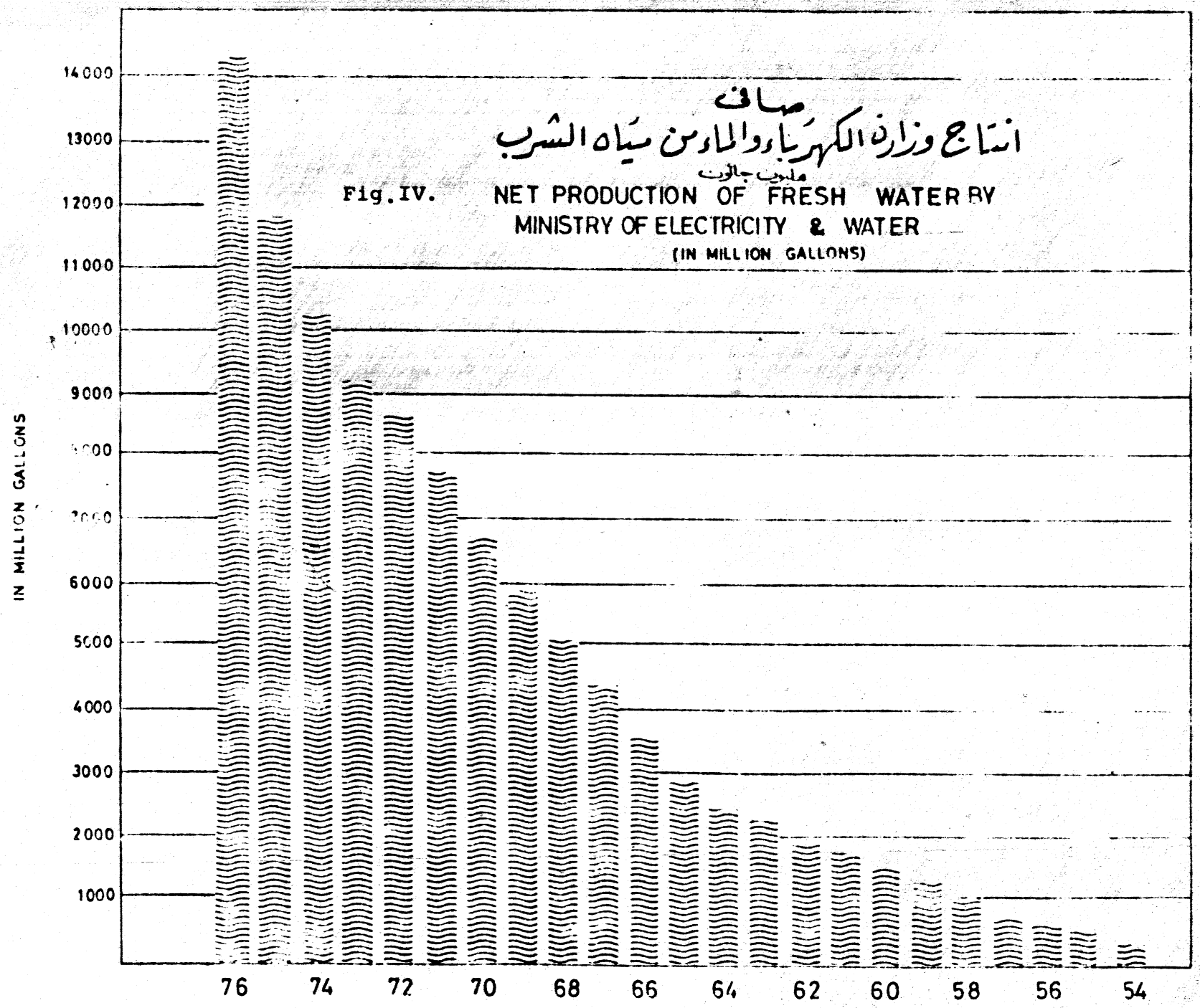

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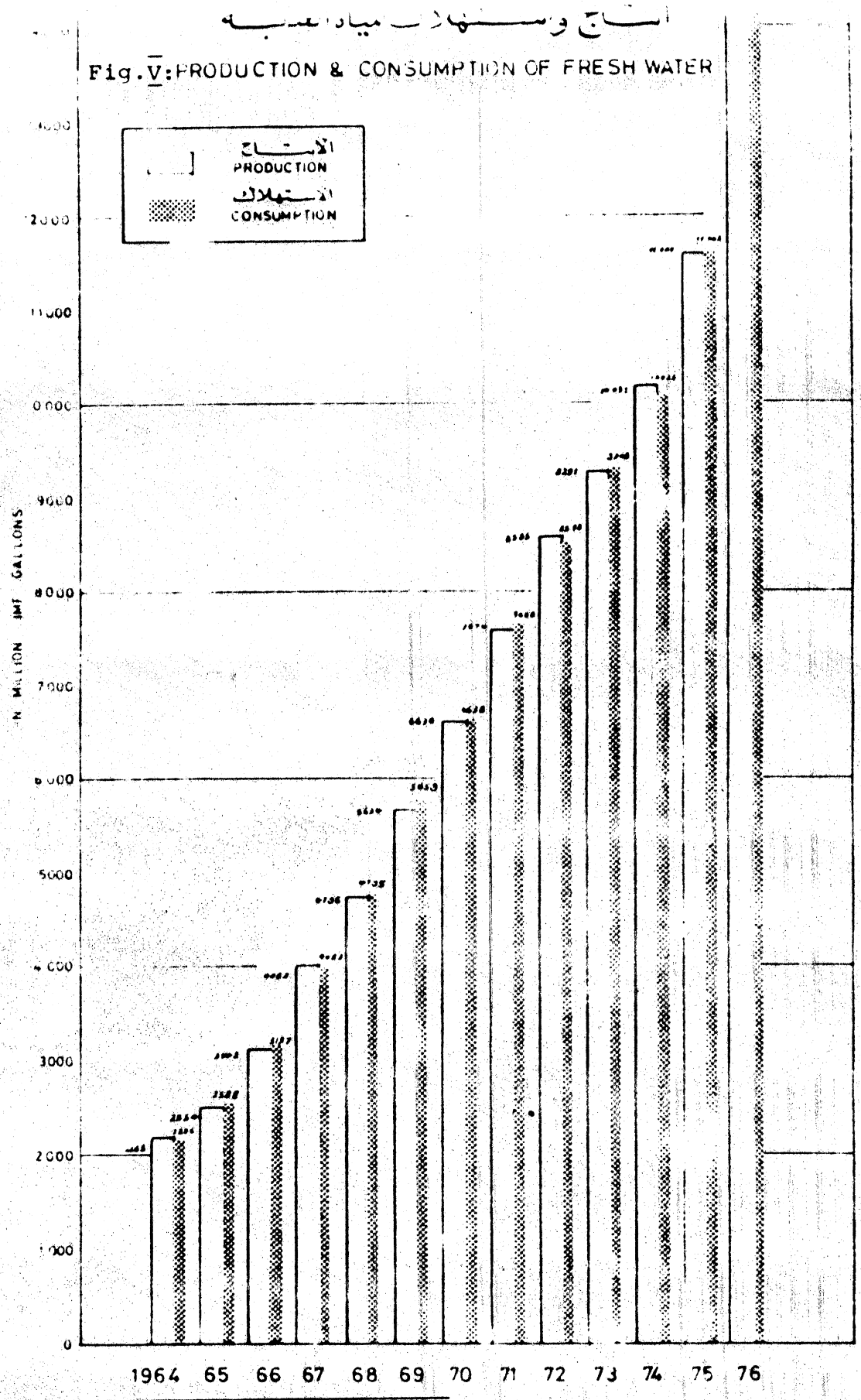

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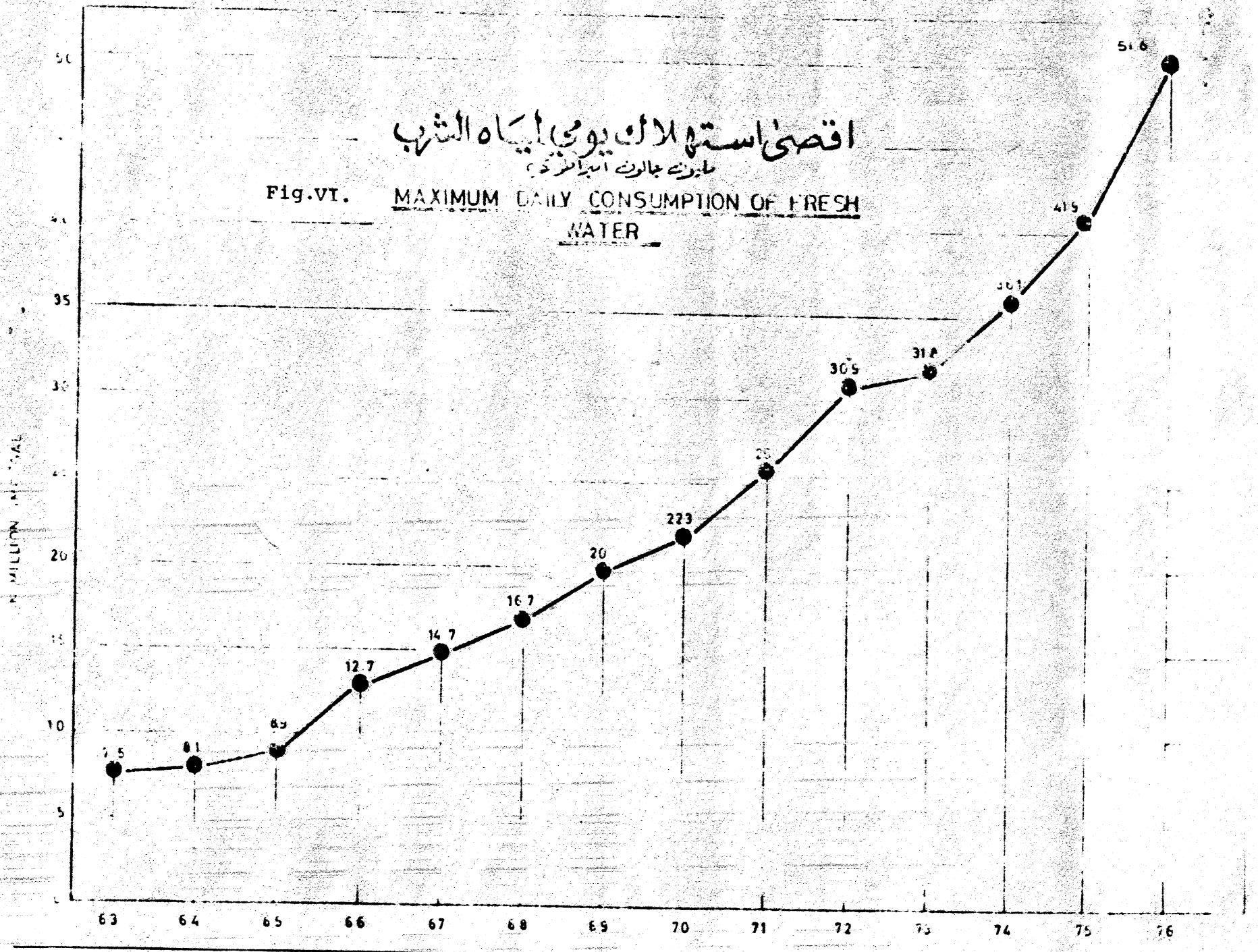
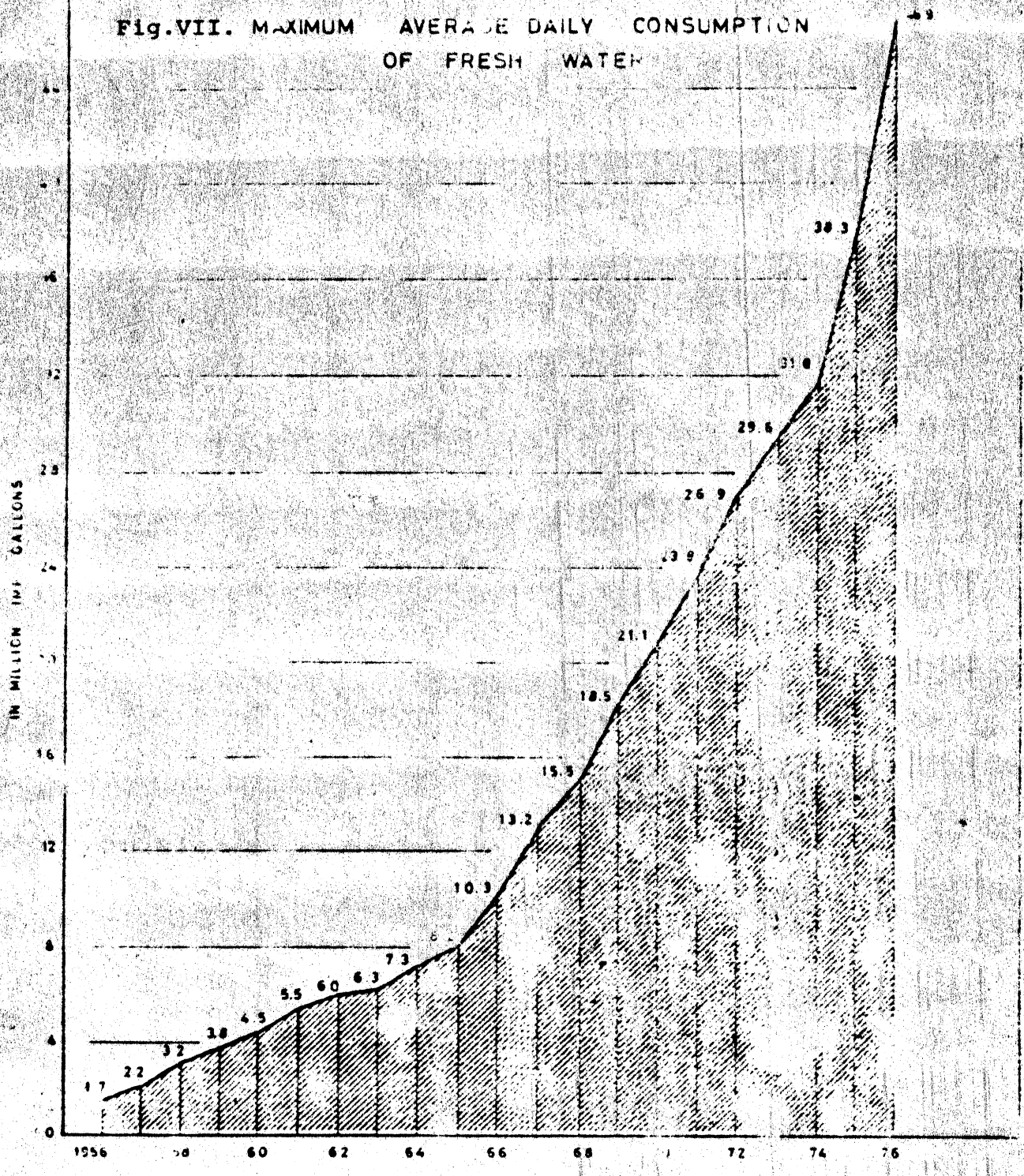


This figure has been obtained from the Statistical Year Book of the Ministry of Electricity and Water for the year 1977.

معدل اقصى استهلاك يومي للمياه العذبة

Fig.VII. MAXIMUM AVERAGE DAILY CONSUMPTION OF FRESH WATER



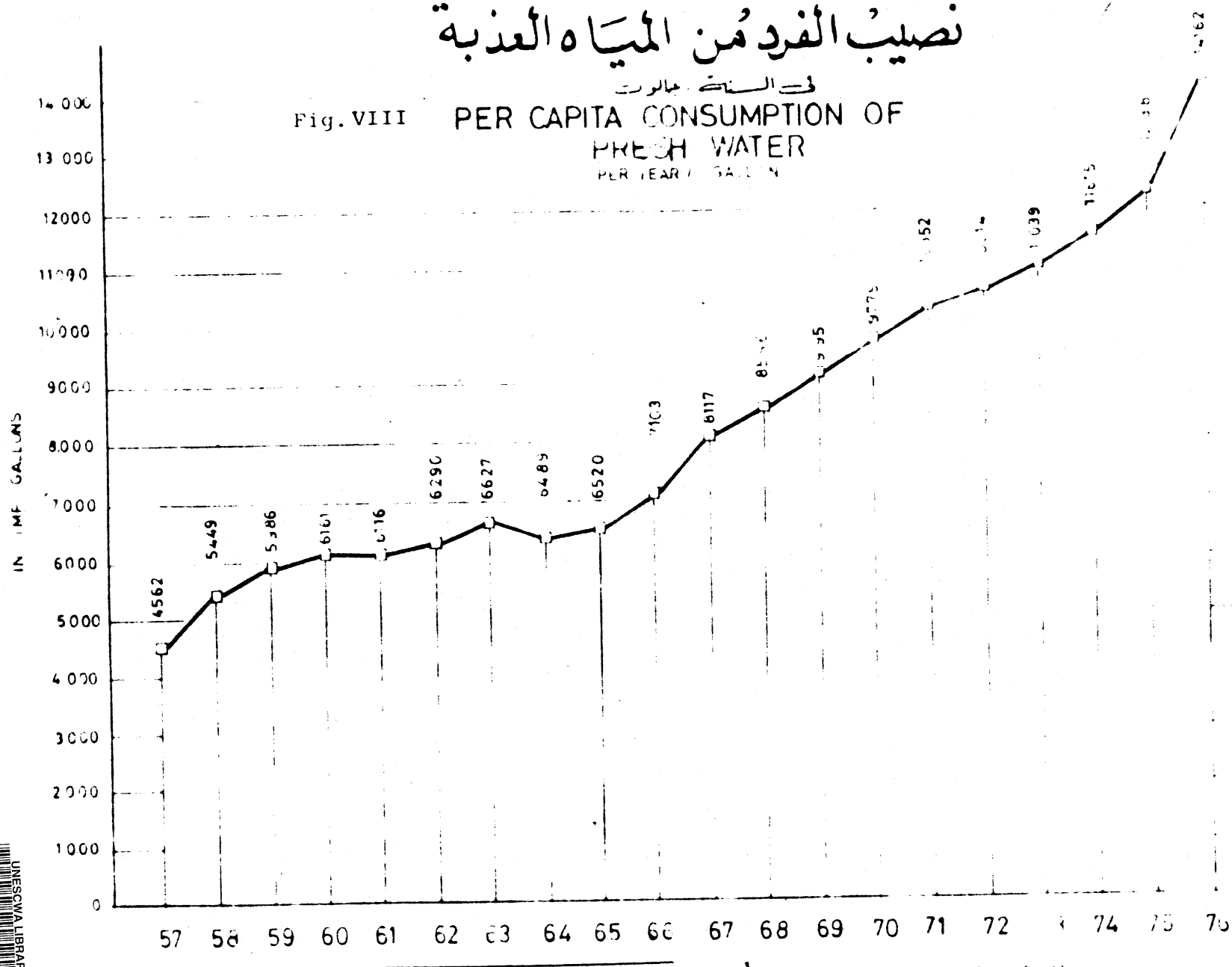
This figure has been obtained from the Statistical Year Book of the Ministry of Electricity and Water for the year 1977.

نصيب الفرد من المياه العذبة

في السنة بالجالون

Fig. VIII PER CAPITA CONSUMPTION OF FRESH WATER

PER YEAR / GALLON



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