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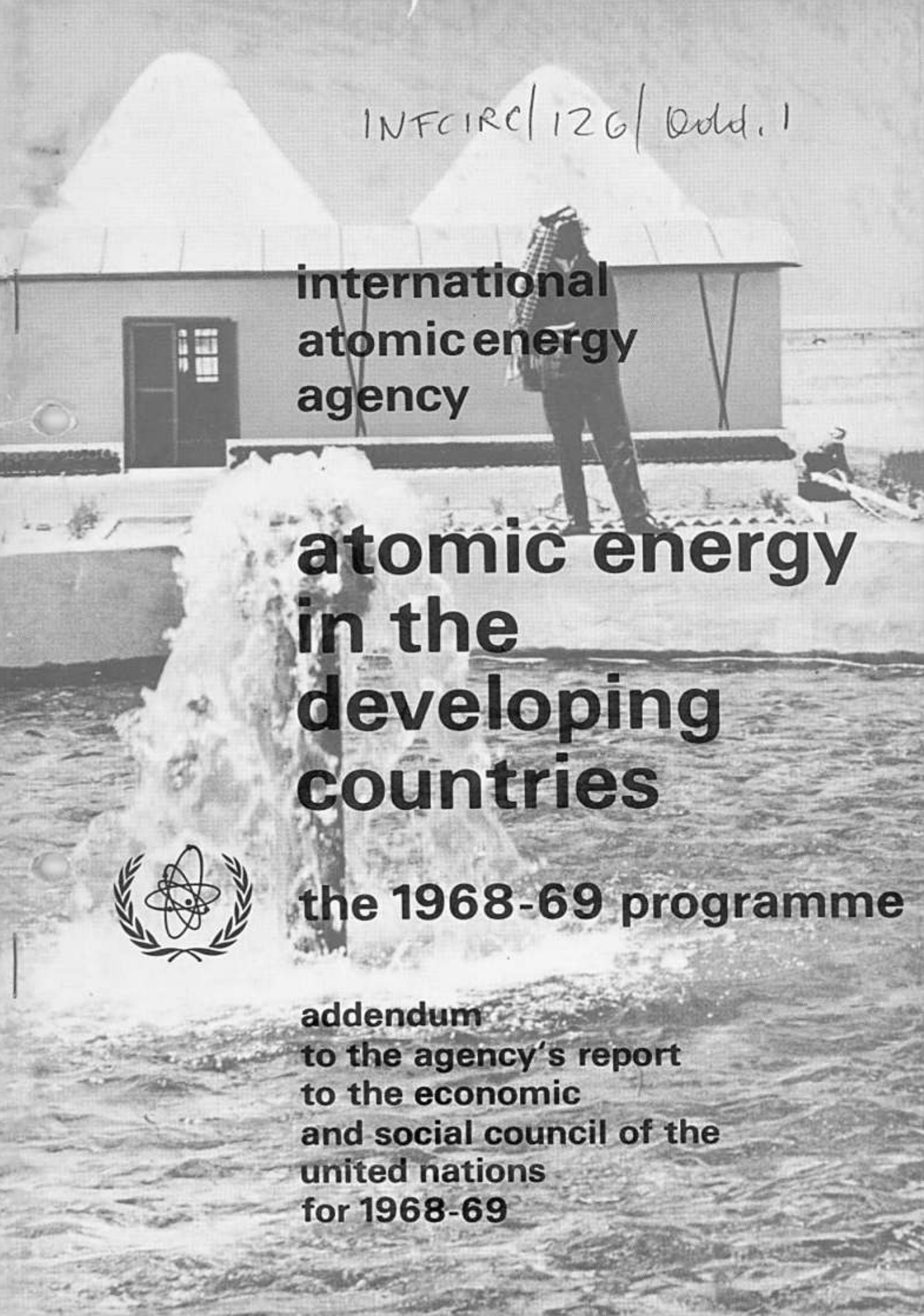
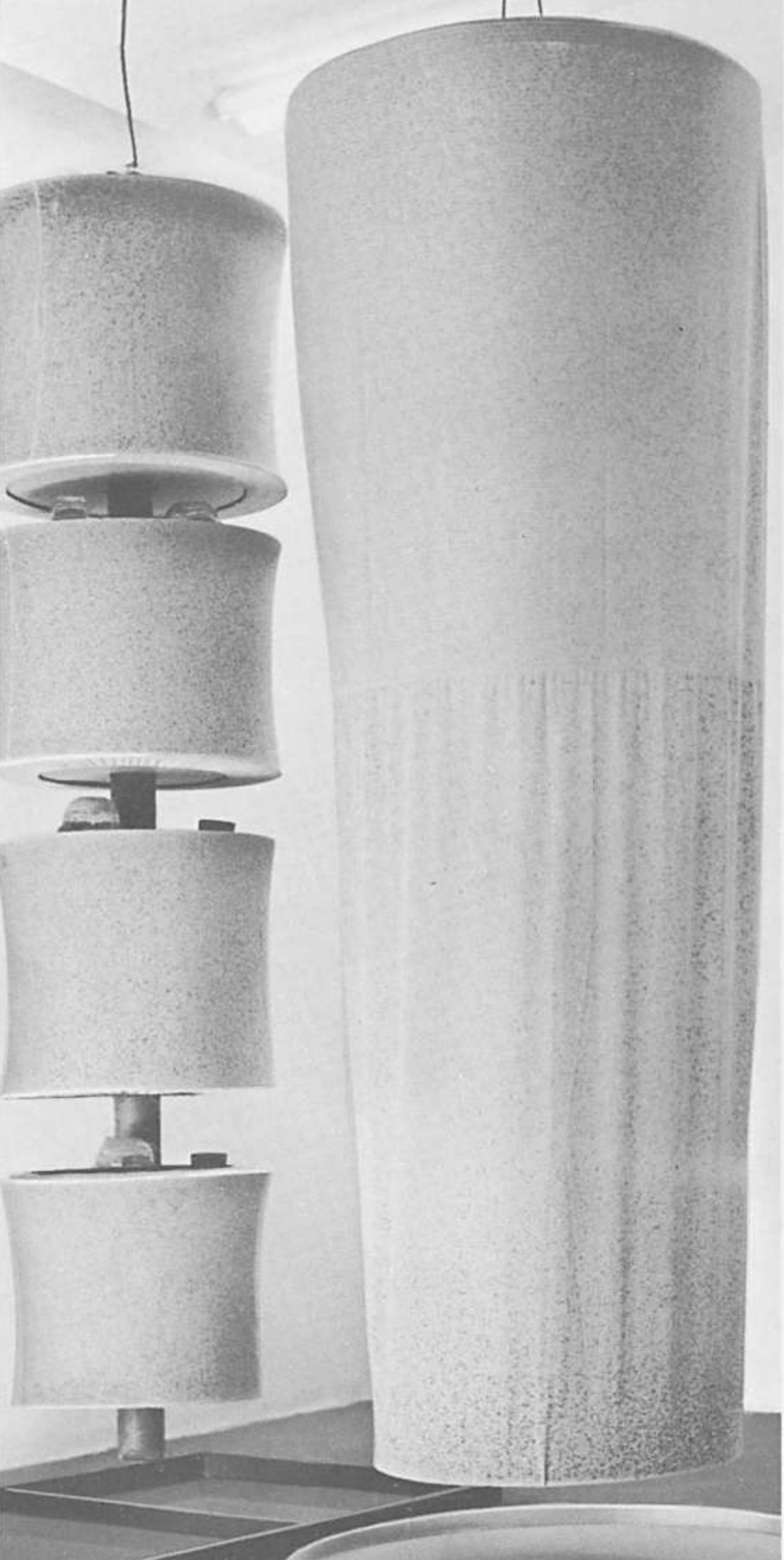


international atomic energy agency

atomic energy in the developing countries

the 1968-69 programme

addendum
to the agency's report
to the economic
and social council of the
united nations
for 1968-69



the first aim
of the
international
atomic energy
agency:

in allocating
its resources
the agency
is required
to bear
in mind:

..."to seek to accelerate the contribution
of atomic energy to peace,
health and prosperity throughout the world"
(statute, article II)

..."the special needs
of the underdeveloped areas of the world"
(statute, article III)

this report tells of the efforts
during the last year to meet these responsibilities.
it is not
a full description of the agency's activities

Cover: *Settlements in the desert. Water found beneath the sands in Jordan enables agricultural centres to be founded for previously nomad tribes. It was thought that water at Jafr came from rainfall seepage fairly close at hand, but isotopic analyses made by Agency experts showed that it originated from sources much further west and that the underground reservoirs were extensive. This was later proved by exploratory drilling. Photo: IAEA/Payne*

Inside cover: *Looking like an ultra modern art form, this is part of the equipment designed for breeding insects in the studies of "sterile male" methods of control. The photo was taken in the Agency's laboratory at Seibersdorf, near Vienna.*

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A list of Member States and details of Voluntary Contributions paid in 1968 and pledged for 1969 are added.

promise, progress and resources

Atomic, or more correctly nuclear, energy holds out the promise of abundant power and plentiful water — the keys to industrial progress — as well as of more food, better health, greater industrial productivity. It is not surprising that the interest of the developing countries is rapidly increasing.

Nuclear energy will make its greatest impact on living standards by producing electric power. Although economic and industrial considerations still favour the advanced nations in considering nuclear power plants, time is approaching when more developing countries can turn to this source of energy.

Development of power from atomic energy has done little so far to narrow the gap between developed and developing countries. Less than two per cent of all nuclear capacity built, being built or firmly planned today is outside the industrial nations of Europe, North America and the Far East. Forecasts show that by 1980 this figure will only have risen to five per cent. The chief reason is that at present nuclear power is competitive with oil, coal, gas and water when produced in plants much too big for most developing countries.

Nevertheless a number of developing countries already have an adequate industrial demand. Some have turned to nuclear power and the number will increase quite rapidly in the next decade. Advancing technology may also make smaller plants competitive and thus attractive to more nations. Other studies are in progress to link the production of power with desalting processes and new industries to open up new agricultural areas. These subjects are examined in greater depth later.

More immediate advantage has been derived from other nuclear techniques. These are the use of isotopes and radiation for research and application in agriculture, medicine and industry. Twelve years ago the founders of the Agency pointed out that these techniques "promised almost infinite possibilities for the advancement of knowledge, for the improvement of industrial processes and for economic and social progress". One of the main tasks since then has been to encourage and assist the realization of these possibilities.

As an example, one striking result achieved has been the use of radiation to bread new high-yielding strains of rice and wheat. These may help to transform the economies of countries where they are staple foods and thus help food production to keep pace with the demands of an ever-growing world population. Other work reported in these pages demonstrates beneficial results achieved and possible in many fields of human activity, such as the saving of millions of dollars by industry.

Limited funds make it essential to focus the Agency's work on problems of high priority, especially where relatively inexpensive pioneering efforts can foster action on a much bigger scale. The 1969 Regular Budget amounts to $11 251 000. For operational purposes an additional $2 000 000 is given as the target for voluntary contributions though the actual figure may be around \$1 400 000. The Agency has therefore concentrated on:

Helping to provide the basic requirements (trained manpower, research and training equipment plus technical advice);
Stimulating research into special problems;
Helping to take advantage of the rapidly growing interchange of scientific information;
Carrying out pre-investment investigations and large field experiments;
Examining major projects, such as power and desalting, and bringing them to the attention of international sources of investment capital.

For several years the funds available for the Agency's own technical assistance programme have been shrinking both in real terms and in relation to demand. In the early years the funds could meet almost all sound technical assistance requests, now the proportion is only one dollar in four. This programme is in a way a seeding of the ground in preparation for larger projects financed by the United Nations Development Programme. It is obvious that to speed up progress the size of the Agency's programme must be increased.

The Non-Proliferation Treaty contains a significant undertaking in this regard. Under one of its Articles, "All the Parties to the Treaty undertake to facilitate, and have the right to participate in, the fullest possible exchange of equipment, materials and scientific and technological information for the peaceful uses of atomic energy. Parties to the Treaty in a position to do so shall also co-operate in contributing alone or together with other States or international organizations to the further development of the applications of nuclear energy for peaceful purposes, especially in the territories of non-nuclear-weapon States Party to the Treaty, with due consideration to the needs of the developing areas of the world." Under the Treaty the potential benefits from any peaceful applications of nuclear explosives will also be made available to non-nuclear-weapon States. In both these areas the Agency will have, and is preparing itself for, important roles.

The world is aware of the vast diversion of vital resources and manpower to nuclear armaments and the risks and wastage that attend and that would follow an extension of the nuclear arms race. Scientific resources and investment capital are particularly precious in the developing countries and must be husbanded. It is also necessary that nuclear materials and facilities should be able to move freely about the world without fear of the spread of nuclear weapons. Within the framework of the Non-Proliferation Treaty and of regional agreements such as the Tlatelolco Treaty for the creation of nuclear free zones, the Agency's Safeguards System, designed to give assurance that these materials are not diverted to other purposes, is thus an important adjunct to nuclear development.

is one in four enough ?

Technical co-operation projects are the mainstay of the Agency's help to developing countries. Finance for them comes from:

— The regular technical assistance programme. This is paid for out of voluntary contributions by Governments to the General Fund.
— Gifts by Governments in kind, such as equipment, cost-free fellowships for students from developing countries and cost-free services of some of their own experts.
— The United Nations Development Programme (UNDP). This also finances technical assistance projects (fellowships, training courses, experts and equipment). In addition it is the source of funds for much larger pre-investment projects financed from its Special Fund component.

From all these sources the Agency has been able to give help worth more than $30 million since 1958. More than 3000 scientists have been trained under fellowships nearly half of them financed by Member States providing facilities) and a further 1300 in training courses. More than 1000 experts have been sent into the field and equipment worth $5 million provided. The total value of help given in 1968 was:

The Agency's regular programme of technical assistance	$1 347 941
UNDP/TA component	$1 133 661
UNDP/SF component	$1 564 652
TOTAL	$4 046 254

In addition, gifts in kind were valued at approximately $650 000.
These combined resources were used to:

— Send 183 experts and six visiting professors to 44 developing countries;
— Furnish equipment to the value of $530 000;
— Award 315 fellowships to scientists from 49 developing countries;
— Hold nine training courses in which 118 persons took part;
— Organize a study tour for scientists from 14 developing countries who visited institutes in Czechoslovakia, Poland and the USSR;
— Send nine scientists from developing countries, under special awards, to 28 countries for research and study purposes;
— Arrange two visiting seminars which toured thirteen developing countries and were attended by approximately 340 persons.

the shortfall

The experts and equipment that the Agency sends out under its regular technical assistance programme play a crucial role in the overall operation. They prepare the way for the larger and longer projects on which the United Nations Development Programme is increasingly concentrating its resources. It is therefore particularly unfortunate that the voluntary contributions made to the Agency's General Fund have never reached more than 72% of the two million dollar target that has been set each year since 1962. They are likely to be even less than 70% in 1969. The effect of this shortfall is shown in the following table and graphs (Figs.1 and 2) showing the worsening position over the years.

The Regular Programme: Assistance Given (in thousands of dollars)

Year	Value of requests received	Value of assistance approved	Percentage
1959	690.0	619.4	89.6
1960	1150.0	599.2	52.1
1961	1277.6	513.1	40.4
1962	1530.0	757.6	49.5
1963	1750.0	857.7	49.0
1964	2400.0	804.6	33.3
1965	2500.0	874.0	35.0
1966	3000.0	902.0	30.0
1967	2600.0	975.0	37.5
1968	3600.0	977.0	27.1
1969	3603.0	[977.0]	[26.4]

It will be seen that:

— In 1959 most requests could be met;

— From 1960-1963 it was possible to meet about half the help requested;

— In 1969 only a quarter of the help requested could be given.

The obvious solution is to increase the funds available for this programme. Frequent appeals to this end have had relatively little effect. In 1968 the Agency tried another approach. It sought voluntary offers of help in kind — in the form of equipment or qualified experts — so as to enable some of the unsatisfied requests for the 1968 programme to be met. It appears that of the 51 outstanding requests, less than 10 may be partially met as a result of this effort.

trends

Member States set their own priorities for assistance and decide which kinds of help are most needed. The trends since 1959 are shown in the following charts (Figs. 3 and 4).

Fig. 1. Value of Requests for Experts and Equipment (in thousands of US dollars)

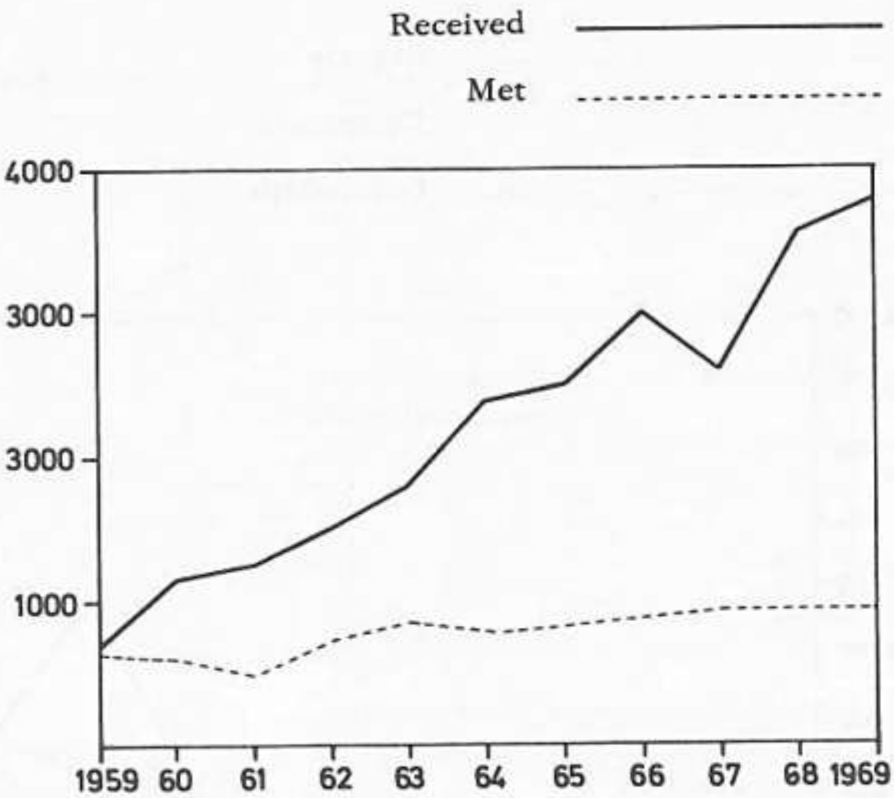


Fig. 2. Percentage Value of Requests which could be met

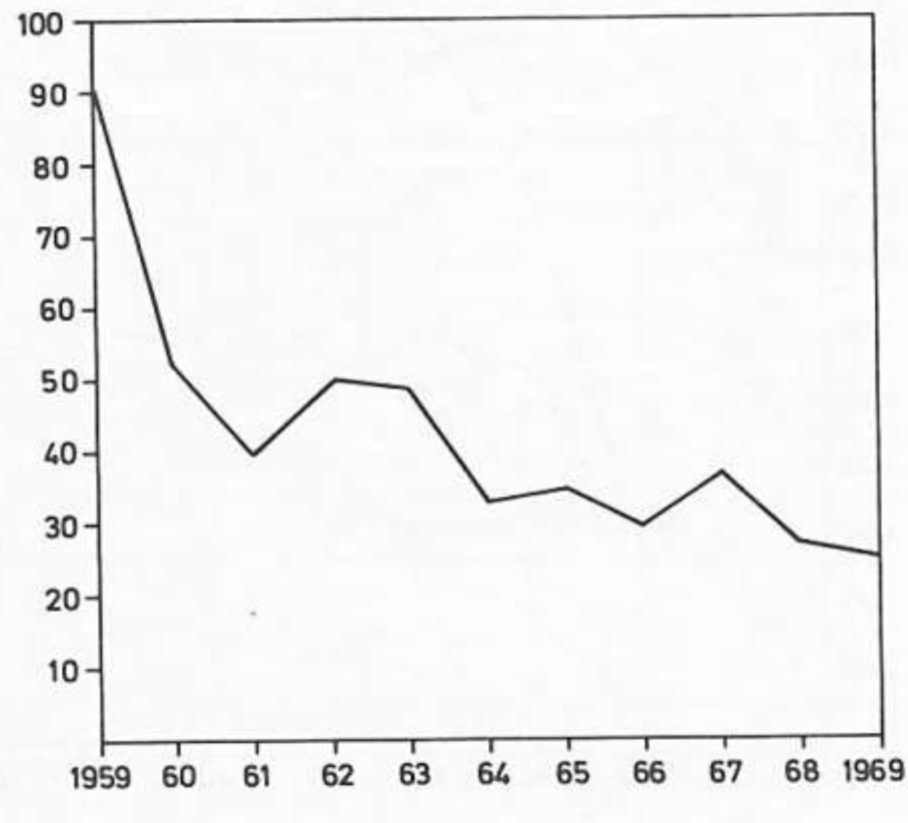


Fig. 3. Trends in the Technical Co-operation Activities of the Agency including UNDP/SF (in thousands of dollars)

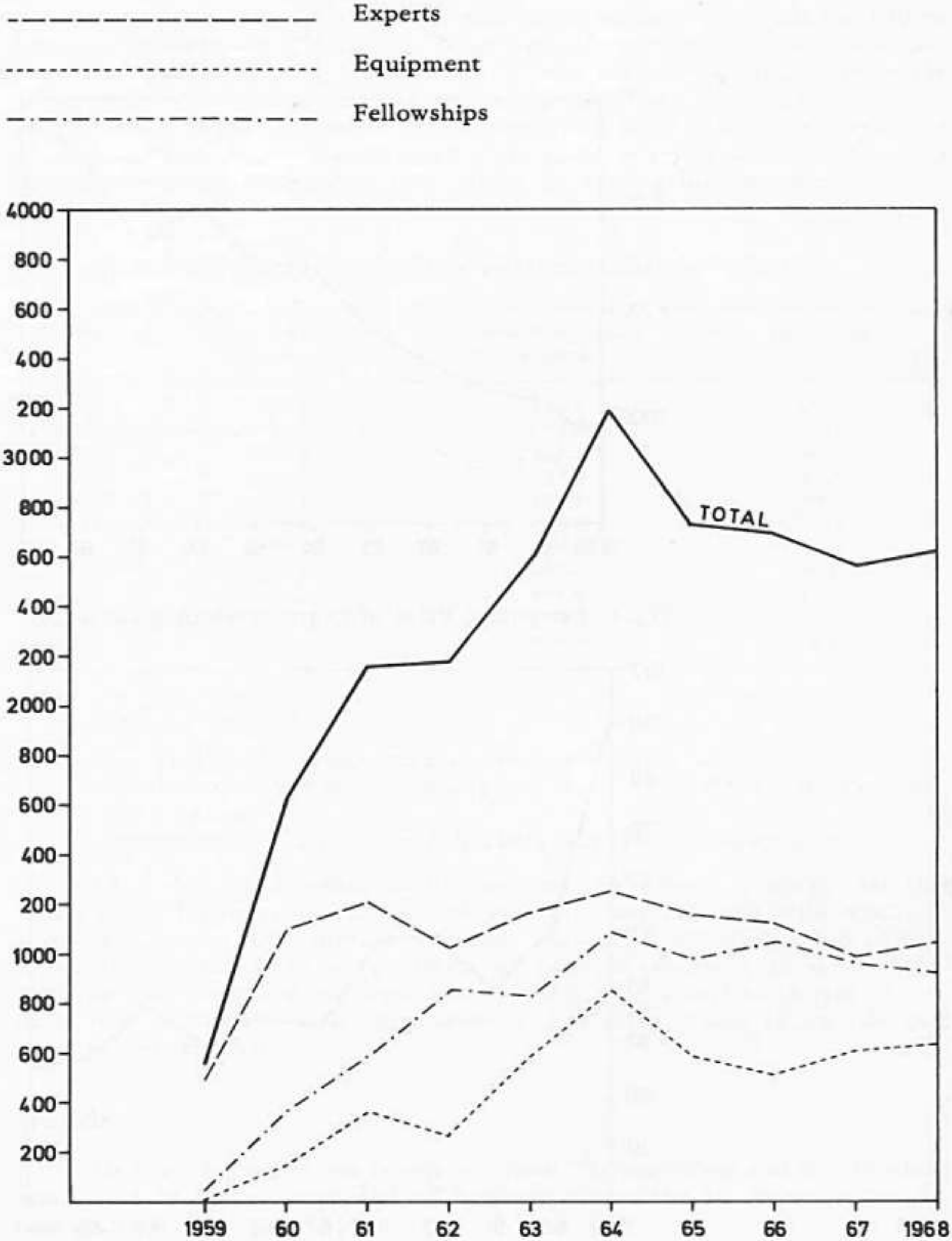
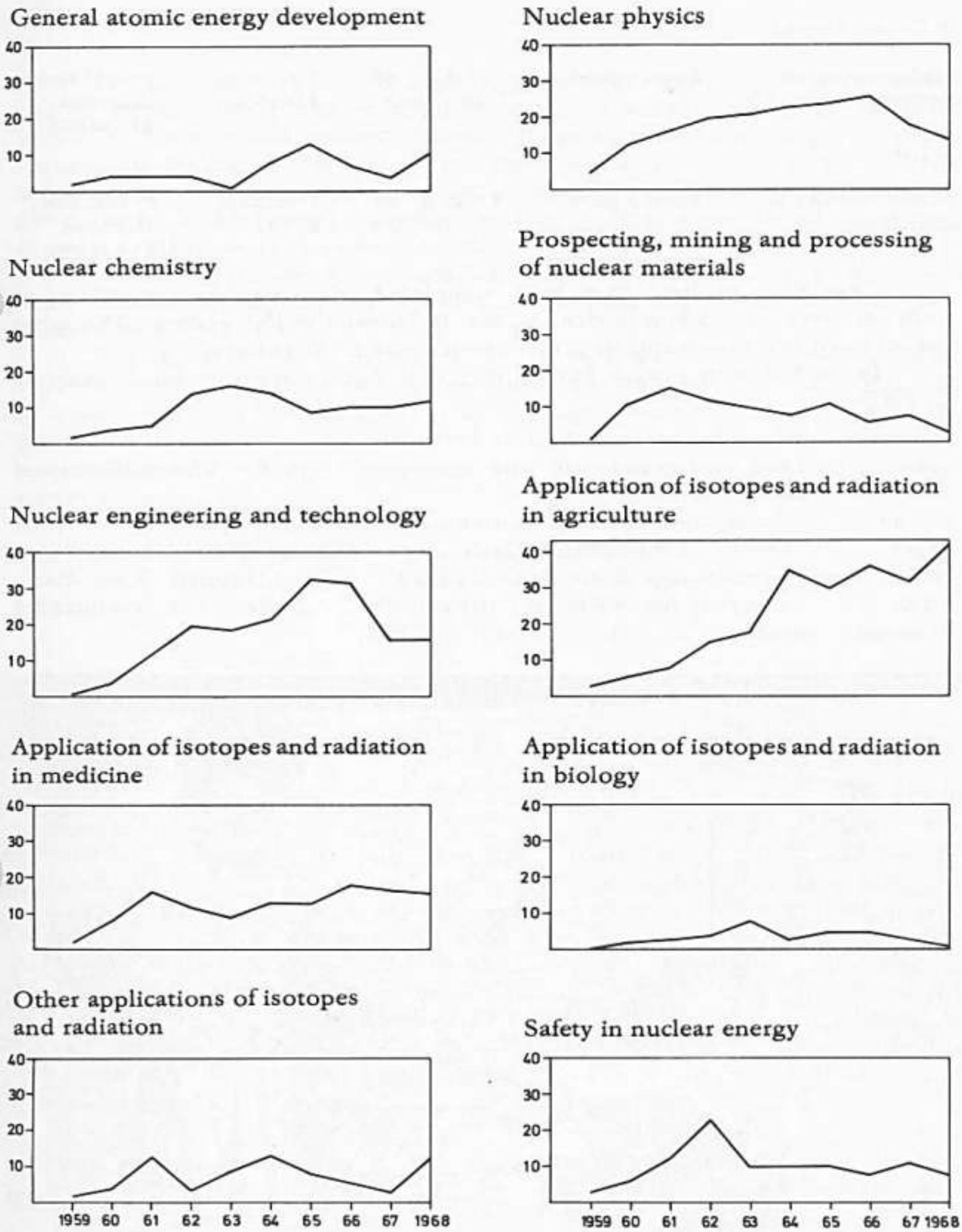


Fig. 4. Technical Assistance Trends. Numbers of experts in the field, including UNDP/SF



larger projects

Two large projects are now being carried out by the Agency on behalf of the United Nations Development Programms (Special Fund). They are:

In Central America

Eradication of the Mediterranean fruit fly	Time, 4 years	Plan signed 29.7.1965	Total cost $2050 300	Special Fund allocation $1 054 000

In India

Nuclear research in agriculture	Time, 5 years	Plan signed 10.10.1968	Total cost $3982000	Special Fund allocation $1 424 000

Two other projects have been completed. One was the pre-investment study on power, including nuclear power, in Luzon, the Philippines. The other was for nuclear research and training in agriculture in Yugoslavia.

In the following Special Fund projects the Agency acted as sub-contractors for FAO:

Dahomey	Pilot development of groundwater
India	Land and water use and management in the Chambal-irrigated area, Rajasthan
Jordan	Investigation of the sandstone aquifers of East Jordan
Niger	Surveys for the agricultural development of the Dallol Maouri
Spain	Hydrogeological investigations in the Guadalquivir River Basin
Africa Regional	Survey of the water resources of the Chad Basin for development purposes

power problems

The number of orders for nuclear power plants continues to grow rapidly and 88 are now being built in addition to the 61 already operating. Increased orders in Western and Eastern Europe, Japan and elsewhere largely offset an appreciable decline in the US, where there was a lull following the massive surge of previous years. In developing regions, the first order for a nuclear power plant in Latin America was placed by Argentina and Brazil is expected to order a plant soon. Detailed nuclear power studies are being made in Chile and Mexico. In South and South-East Asia, India announced a third plant while China, the Republic of Korea and Thailand are making, or have completed, feasibility studies.

It is expected that world nuclear capacity will reach 310 000-340 000 MWe by 1980, about one-eighth of the total power generated in the world. Of this, it seems that only 5% may be in developing countries (less than 2% of the plants now included in programmes will be outside the main industrial regions).

Three broad groups of questions must be answered in launching a nuclear power programme:

- Is the programme economically justifiable?
- Is it technically feasible in the circumstances of the country (or can it be made feasible?
- If economically and technically feasible, how can the investment capital be found?

economic thresholds

Size (and, therefore, cost) represents the chief barrier. The size at which nuclear power stations are at present competitive is around 300 MWe. This is a very large power station. In special circumstances, this threshold may be reduced, but generally speaking, the larger the nuclear plant, the better its competitive position. The largest single operating unit, whether nuclear or not, in an electric power system (grid) should not produce more than a relatively small part of the total output of the grid, otherwise the whole system is affected if, for instance, there is a plant failure. But each situation has special characteristics that must be studied in detail before deciding to incorporate nuclear power. In most cases, there must be a detailed economic feasibility study that will look not only at a single plant but at the whole system as it exists and as it will expand.

◀ *Regional co-operation. A Chinese trainee with an Indian expert operating a neutron spectrometer at the Philippine Atomic Research Centre. The Agency supports this effort to develop local facilities. Photo: IAEA / Goldberger*

Leaving aside special cases, nuclear power is likely to be attractive to developing countries only when they have gone some distance towards industrialization. Moreover, those countries that have cheap fossil fuel (oil, coal or natural gas) or hydroelectric power, should, and usually do, develop these first. These two factors largely explain why most countries in Africa, the Middle East and Latin America do not yet seriously contemplate nuclear power. The absence of cheap alternatives, on the other hand, has helped to make nuclear power attractive to India, Pakistan, China, Korea and Thailand, countries in South and South-East Asia where industry is already will established.

This is the present situation. It could be changed however if the techniques of small and medium size reactors were developed to make them economically competitive.

It may therefore well be worth stimulating the interest of manufacturers in designing cheaper middle-sized nuclear power plants, by giving them authoritative information about the potential market for such plants. To this end, the Agency convened a meeting in June 1968 to review the technical and economic prospects of such plants. The meeting confirmed that there is a sizeable potential market for medium-sized plants. The nuclear industry in certain industrial countries seems eager to explore this possibility. The Agency is continuing its studies, its market survey, and has invited a number of countries to take part in a co-operative study.

technical aspects

The basic conditions necessary to start a nuclear power programme in a developing country include:

— A nucleus of trained scientific and technical manpower to organize and carry out the programme and to help plan, build and operate particular plants;
— The basic industrial plant needed to carry out servicing and repairs and to manufacture at least some of the components of the nuclear station;
— Basic legislation on nuclear safety and on related legal questions as well as effective executive organizations.

Before nuclear power stations are built, there must be detailed safety and siting studies.

Efforts made during the year are given below:

The Agency awarded 46 fellowships and sent out 20 experts on topics directly related to nuclear power and desalination to help create the basic expertise needed in the countries concerned.

The Agency advised Brazil, Cyprus, Czechoslovakia, Greece, Indonesia, Korea, Leganon and Singapore on the framing of basic legislation. A training course acquainted officials from 31 developing countries with the problems of setting up competent nuclear energy bodies, nuclear safety laws and regulations, and third party liability and insurance.

In June, the Agency and the Economic Commission for Asia and the Far East (ECAFE) held a briefing seminar on nuclear power for Asia and Far East Countries. This brought nuclear energy experts directly in touch, for the first time, with many of the senior planners and executives of power utilities in a developing region. A more comprehensive meeting may be held in Asia in the near future, and similar ones in Latin America.

Advisory missions were sent to Brazil, Greece, Kuwait, the Republic of Korea and Yugoslavia to help plan nuclear power programmes.

Missions went

— to China (Taiwan) and Thailand — to advise the Governments concerned about the selection of locations for proposed nuclear power plants;
— to Argentina, Brazil, Colombia, Mexico, Uruguay, Venezuela — about the handling of safety problems;
— to Chile and Pakistan — about problems arising from disposal of radioactive wastes.

One of the problems that faces developing countries is to arrange transport of nuclear cargoes — especially highly radioactive spent fuel — between distant ports at reasonable costs, and to get port and canal authorities to accept such cargoes in transit. In October a joint meeting of the Agency and the European Nuclear Energy Agency (ENEA) in Monaco brought together experts in insurance, nuclear industry, shipping and law, to study the problems of liability and insurance in "sea carriage of nuclear substances". The meeting showed the need for better knowledge of the risks involved and for wider acceptance of the IAEA Vienna Convention of 1963 on Civil Liability for Nuclear Damage. This Convention has so far been adopted by Argentina, Bolivia, Cameroon, Cuba, the Philippines, Trinidad and Tobago and the United Arab Republic.

The Agency's Transport Regulations are already applied by all European authorities responsible for road, rail and inland water transport. Further progress has been made in getting them accepted by worldwide bodies such as International Air Transport Association (IATA).

finding the money

The main problem is to find the large amount of investment capital needed for a nuclear power programme, which should consist of a planned series of plants.

The current costs of a single nuclear power plant range from $50 million for a 200 MWe plant to approximately $140 million for the largest plant now on order (1100 MWe). The investment required for a large-scale agro-industrial project may be of the order of $1000 million.

The Agency is not a financing organization. It may nevertheless assist Member States to make arrangements to secure the necessary financing from outside on condition that by Statute it is "not required to provide any guarantees or to assume any financial responsibility for the project". The Agency had several consultations during the year with the Secretariat of the International Bank for Reconstruction and Development (IBRD) with regard to financing nuclear power in general. It draws the Bank's attention to projects which it has helped to evaluate. Contacts have also been made with the Asian Development Bank.

All the present nuclear power projects in developing countries are being financed with the help of loans or grants from the supplying country, i.e. bilateral aid. It is hoped that, in the future, international sources of finance will play a bigger role. Not only the strict economics must be considered but also the indirect advantages that a new technology brings to a developing country. Nuclear power for instance gives a strong incentive to many other industries. It also increases the need for local training of scientists, engineers and skilled workers in many different fields. It is a powerful stimulus to the general scientific and technological development. The technological "spin-off" that has influenced advanced countries to go in for large nuclear energy programmes is equally important to developing countries. An additional advantage is that nuclear power is much "cleaner" than burning coal, oil or gas, and its social cost in the form of pollution by products of combustion is much smaller.

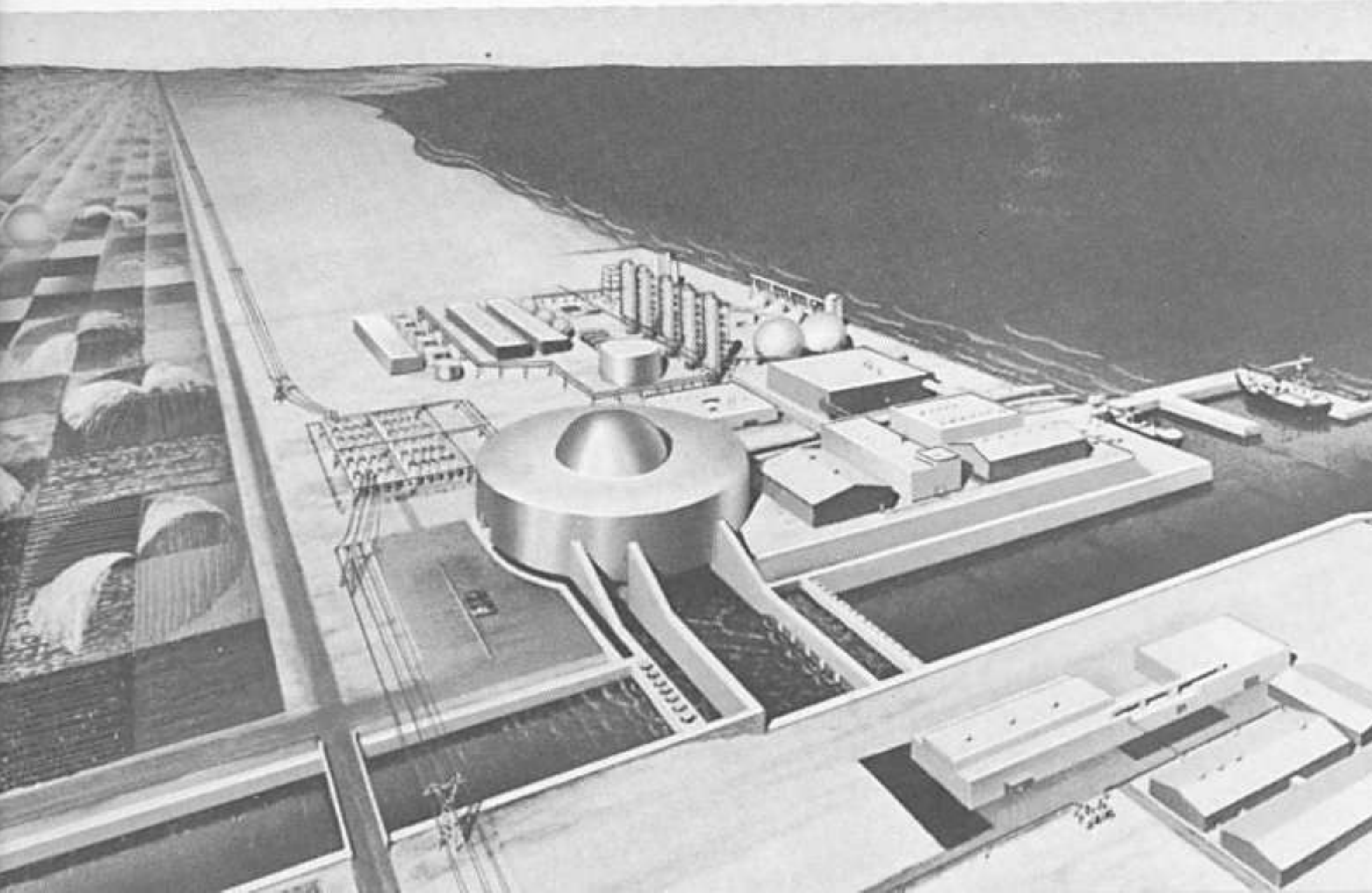
If an agro-industrial complex were established in a hitherto arid region it could look like this. The ▶ artist's impression was prepared by the Oak Ridge National Laboratory

fresh water and new industries

Studies have shown that nuclear desalting can already produce fresh water cheaply enough for industrial use. By the 1980's, it will probably be cheap enough for municipal supplies and for some kinds of agriculture. Nuclear desalting will then be especially interesting for those arid countries where the climate allows farming all the year round. Developed and developing countries alike share the need for cheap and plentiful water. Nuclear desalting may thus offer an opportunity for the advanced countries to perfect a technology that can be used relatively soon in the developing world.

The most urgent need is to get the practical experience and the "hard" economic information that can be gained only by building and running a nuclear desalting plant. One plant is now being built in Chevchenko, USSR. It will produce 150-250 MWe and up to 66 000 000 gallons (250 000 cubic meters) of water per day. Israel, Mexico and the UAR, as well as the USA, are studying various nuclear desalting or dual-purpose (desalting/electricity) projects. Because of the promise that the technology holds for the developing countries, the IAEA is following these projects closely and is vigorously promoting the exchange of information.

After three years of work, the first phase of a Mexico/USA/IAEA study of a dual-purpose nuclear plant was completed. The plant recommended would consist initially of one unit, producing 1000 million gallons of fresh water per



day and 2000 MWe, other units of the same size to be added later. The project is now being examined by the two Governments. The next steps are likely to be detailed technical studies, and cost estimates.

Growing interest is being shown in nuclear agro-industrial complexes as a possibility for the future. These would be very large plants that would produce nuclear power at perhaps half of today's cost, produce desalted water for agriculture and supply the needs for large energy-intensive industries, such as fertilizer production. The Agency is taking part in a study that the Oak Ridge National Laboratory (ORNL) of the USA is now carrying out in the Middle East. After a detailed preliminary report Oak Ridge sent a team of experts, accompanied by IAEA staff, to Jordan and the UAR in October. The studies will analyse the feasibility and costs of constructing large agro-industrial complexes at one or more locations in the Middle East. They will include a plant for pilot and demonstration projects and an outline of the steps needed to carry out a full-scale project.

To promote the exchange of information on nuclear desalting, the Agency convened a symposium in Madrid in November 1968 which attracted nearly 300 participants. The symposium discussed reports on:

- the economic feasibility of agro-industrial complexes;
- experience in starting up a 50 million gallons a day test module in the US;
- dual-purpose projects and agro-industrial complex studies in India, Israel and Spain;
- the reasons for the increases in cost estimates for a projected plant in the US;
- studies for using desalted water together with conventional water supplies.

peaceful uses of nuclear explosions

So far only the USA has published information about the peaceful uses of nuclear explosives. They offer promise for civil engineering works (canals, ports, mountain passes, etc.) in which earth must be moved on a very large scale and as a means of unlocking underground natural resources or providing storage space for them. However, the technology is still at an early stage. Many uncertainties will have to be resolved before it can be put to industrial use on a wide scale. In the international field, the first need is to obtain and spread more information about the potential of the new technology, and its technical limitations and costs.

The Agency staff has taken part in briefing sessions on two peaceful nuclear explosive operations in the US. The most recent was the "Gasbuggy" experiment designed to test the effects of using a nuclear explosive to release large quantities of natural gas, inaccessible to current conventional techniques. The Agency also gave technical assistance to Panama in 1966 on the safety aspects of the use of nuclear explosives.

The Agency is now launched on a gradually expanding programme which will concentrate at first on world-wide information exchange.

◀ *Students at a course in Ankara arranged jointly by the Turkish Government and IAEA learn how to use isotopes in water flow studies. Photo: IAEA / Halevy*

finding nuclear fuels

The needs for uranium concentrates, according to available information, are expected to grow from about 23 000-26 000 short tons in 1970 to three or four times that figure in 1980. The cumulative demand for uranium by 1980 is expected to be from 560 000-740 000 short tons of concentrates. Because of the growth of nuclear power, these forecasts are much higher than a few years ago and they have brought about a resumption of uranium prospecting in many countries.

The IAEA and the European Nuclear Energy Agency are jointly continuing to collect and publish data on world uranium resources and of production facilities. A report on uranium production outside the socialist countries was published by the two organizations in December 1968.

Thorium, which is more plentiful than uranium, may, in time, become an alternative fuel for nuclear power plants. Abundant resources exist in several developing countries, such as Brazil, India and the UAR. A recent Agency meeting has examined the problems that have prevented the wide-scale use of thorium in nuclear power plants. One difficulty is the absence of industrial facilities to fabricate and reprocess thorium fuel elements, while such plants are relatively plentiful in the case of uranium.

Technically advanced countries at present account for by far the greatest proportion of the output of nuclear fuels. They have provided a valuable foreign exchange earner for several of these countries. In recent years there have been promising new discoveries in certain African states. Large-scale systematic prospecting is likely to lead to the finding of large new reserves in many parts of the world. A vigorous campaign in this direction may thus help to share more widely the benefits that result from the growth of nuclear power.

The Agency is helping its Member States by technical advice and missions. In its 1969 technical assistance programme it will give help in the development of nuclear raw materials to Chile, Ethiopia, Greece, Guatemala, Mexico, Peru and Tunisia. It is encouraging research on cheaper methods to recover uranium from low-grade ores and as a by-product from other mineral production.

In Tunisia an IAEA expert leads a team prospecting in areas where uranium might be found. Photo: ▲ IAEA / Moir

Meetings to develop full use of research reactors have been held in a number of regions, including Bangkok ▶ (Thailand), where this reactor for training and research was built.

using research reactors

There are now 378 research reactors operating, 41 of them in developing countries. They represent the first steps towards experience of nuclear power. They are also unique tools for the practice of many kinds of basic and applied scientific research and in this way can help to stimulate other disciplines. The Agency has a special programme to encourage the full use of these reactors and give a general spur to science and technology in a developing country.

In March 1969, the Agency held a Regional Research Reactor Utilization meeting in the Philippines. This was the twelfth in a series of such meetings; six have been held in Asia, three in Latin America and three in Africa, Europe and the Middle East. These meetings bring together scientists from centres in the region to discuss common problems and launch projects for mutual aid or co-operation. Scientists also come from leading centres abroad to help conduct the discussions. The topics vary from highly-specialized problems of physics, such as measurements of neutron flux, to broad questions of nuclear engineering education. These meetings thus give a general stimulus to research and also encourage the use of reactor centres for the practical work of gaining experience useful for future operation of nuclear power stations. The discussion of specialized physics problems often has a direct practical value.

A topic recently discussed is activation analysis. This is a way of using reactors to carry out analysis involving extremely small amounts and thus to obtain information which may be important to farmers, doctors, chemists, metallurgists — sometimes even the police. Another subject — hot atom chemistry — can lead to the production of specialized medical work calling for the materials to be available almost direct from the reactor.

Related to the above programmes are two joint regional projects. In Asia and the Far East, the IPA project (India/Philippines/Agency) uses equipment and experts from India, with the Agency's help, to train scientists in the Philippines in the techniques of neutron spectroscopy, which is an important tool in solid state science and technology. The result has been to strengthen the capacity of the Philippine Atomic Energy Centre to undertake both basic and applied research and has helped to initiate similar activities in several other countries in the region. IPA will be followed by a new and broader agreement. In Europe, the NPY project (Norway/Poland/Yugoslavia) has enabled all the countries concerned to work more effectively on many aspects of nuclear power research.

Advisory services are regularly given or arranged to reactor centres. Thus, for instance, the nuclear power survey mission that went to Brazil in 1968 also advised the Brazilian authorities about the programme of their nuclear research centres. Help has been given to Uruguay in planning a research reactor, Iran and Iraq in the safe operation of their reactors and Spain in the commissioning of a new research reactor. Services will be given to China, Indonesia, Iraq and the Republic of Korea in 1969 and to more countries as requests are received.

the versatile isotope

The next few sections describe how the Agency helps developing countries to take advantage of the manifold practical applications of radioisotopes and radiation. The equipment they require is usually small and their cost relatively low. The equipment they require is usually small and their cost relatively low. They can be used in almost every country to help increase food supplies, to combat disease, to improve and cheapen industrial output and to develop supplies of water. They have become a standard tool in most branches of applied research. The main problem retarding their use in developing countries is ignorance of their potential and shortage of qualified scientific and technical personnel. Since the start, the Agency has devoted a large part of its work to overcoming these barriers.

These techniques are in most cases a way of achieving a result that may also be obtainable by conventional means. Whether a nuclear or a conventional approach is used is usually a question of the relative effectiveness and cost, and availability of suitable equipment and trained staff. Since nuclear techniques provide tools for medical, agricultural and industrial scientists, doctors, hydrologists, and engineers, they are thus also of interest to many organizations in the United Nations family. In promoting their use, the Agency co-ordinates closely with these organizations.

Technical assistance is the Agency's chief means for helping developing countries. Other methods are:

Co-ordinated research programmes: These seek to focus a known technique on problems common to developing countries. Groups of research centres in selected countries co-operate with the Agency in concerted attacks on particular problems. Centres in technically advanced countries often co-operate on a "cost-free" basis. Regular consultations ensure co-ordination. The Agency's own laboratory provides support for many such programmes.

Headquarters support: The Agency increasingly uses experts from its own staff for short-term assignments in developing countries.

more food, better quality

Nuclear techniques are used to:

- obtain better use of water and fertilizers;
- breed better varieties of plants;
- increase plant production;
- control insect pests;
- increase the food yield from domestic animals and improve animal health;
- protect food, both in the field and in storage.

The biggest economic impact so far has been:

- in breeding new plant varieties;
- in obtaining as large a crop as possible from the minimum use of fertilizers.

In 1964, the Food and Agriculture Organization (FAO) and the Agency pooled their resources in a Joint Division of Atomic Energy in Food and Agriculture. The United Nations Advisory Committee on Science and Technology meeting in Vienna in November 1968 urged the FAO and the IAEA to increase the resources available to the Joint Division, and especially its work on applying nuclear science techniques to develop varieties of food crops with a high and balanced protein content.

more grain

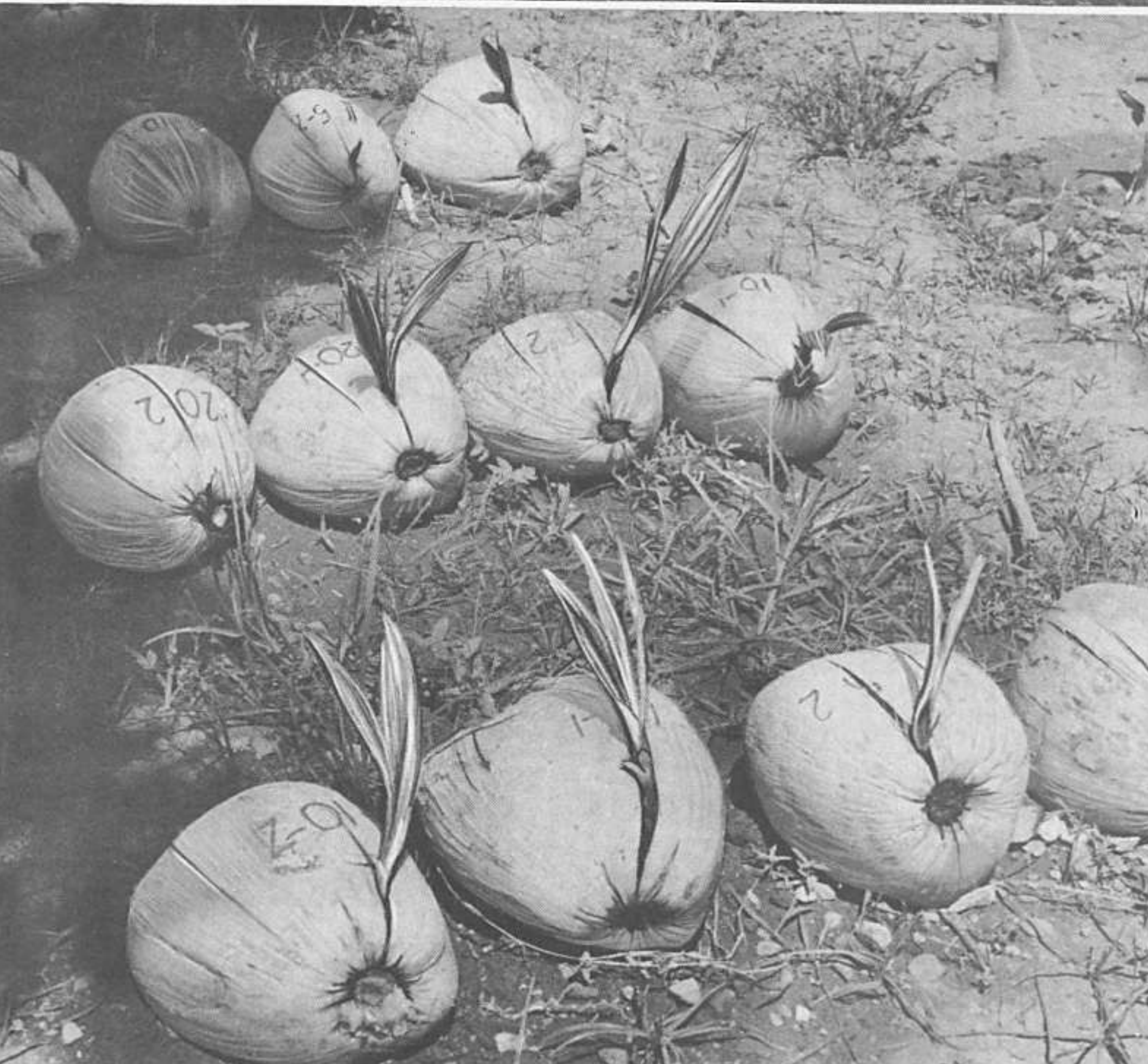
The plant breeding programme is concentrated on rice and wheat and on applications to increase protein quantity and quality of food grains. The highest yielding rice variety in Japan and the most popular wheat variety in India were bred following radiation treatment of seeds. During the past year, the scientists from ten countries co-operating in the rice mutation breeding programme held their fifth meeting in Japan and also reported:

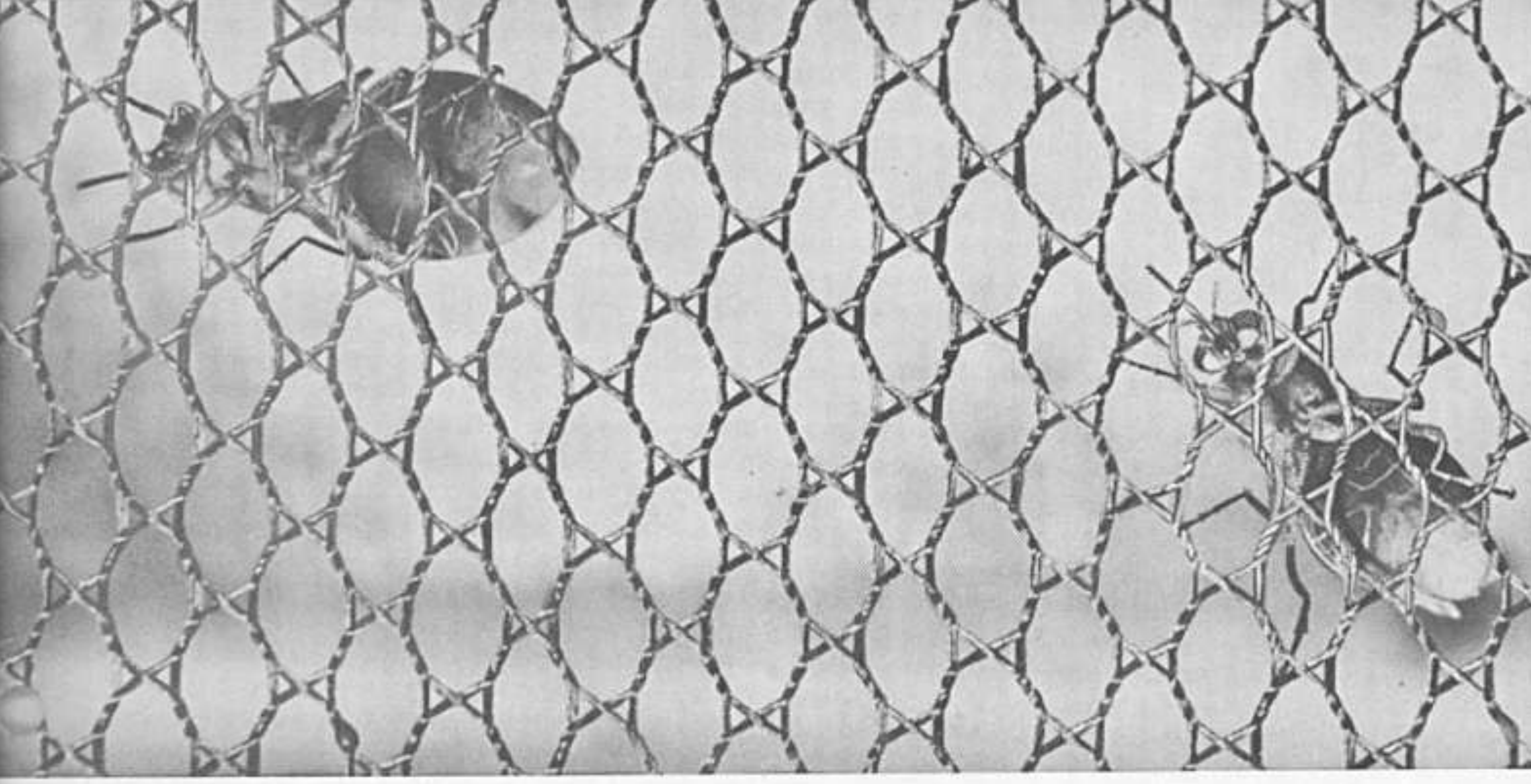
- doubling of protein content;
- a gain in some instances of 60 days in maturing time;
- a number of high yielding, early and stronger stemmed mutant lines of rice;
- successful transfer of the desirable characteristics between indica and japonica rice (the two main types of rice grown in Asia), following radiation treatment and selection.

As a result of changes in seed properties induced by radiation, the wheat on the right is shorter but stronger to resist winds and disease, and gives higher yield. ▶

KONTROLLE
15 KRAD GAMMA
120
110
100
90
80
70
60
50
40
30
20
10


PLACEMENT OF FERTILIZER
NITROGEN (N15)
BROADCAST & INCORPORATED
PLACEMENT
5 cm. DEPTH
10 cm.
20 cm.
CHECK
N-LEVELS :
NO NITROGEN
VARIETY :





Early studies are in progress to see whether the tsetse fly can be controlled by nuclear techniques. These ▲ flies were bred at the Agency's Seibersdorf laboratory.

Italian **Durum** wheat mutants, which have been grown in FAO/IAEA trials in 22 countries for four years, continue to show superior results. Two of the mutants have now been released to farmers in Italy.

In June 1968 the Joint Division launched a co-ordinated research programme using radiation for breeding purposes and isotopes for mass screening of mutants to discover the seeds that contain the highest protein content or nutritionally important amino acids.

improving use of fertilizers and water

For the farmer in developing countries, fertilizers are often scarce and costly. Water must be used as efficiently as possible. Isotope techniques have become a valuable tool in making studies of the best use of these two crucial commodities.

The results of an FAO/IAEA programme on optimum use of nitrogen and phosphorus fertilizers in maize and rice growing are now being put to use by farmers in India and some other Asian countries.

The Joint Division has also launched a co-ordinated programme, chiefly in the Near East and Latin America, to use isotope tracers in optimizing fertilizer use in wheat production. A co-ordinated programme started in 1966 on tree crop fertilization and the first part is due to be completed in 1970. The main tree crops under study are palm oil, coconut, citrus, coffee, cocoa and olive.

▲ *In a Philippine ricefield this photo was taken during an **IAEA** controlled experiment on fertilizer in which twelve countries took part.*

◀ *More meat in the coconut is possible from the use of radiation to bring changes in the seed stage. These nuts were grown during an experiment in the Philippines.*

▲ *The 1968 wheat experiment. Some of the crop samples arrive at Seibersdorf.*

control of insect pests

For three years, IAEA and FAO have been carrying out on behalf of the UN Development Programme a large-scale field experiment in co-operation with Mexico, the five Central American countries and Panama, on the use of radiation-induced sterility as a means of controlling or eradicating the Mediterranean fruit fly. This is the main insect scourge of citrus growers in the region. The experiment is now reaching completion. The feasibility of this technique has been demonstrated, but it will have to be carried out on a considerably larger scale in view of the problems of reinfestation. The United States and Mexican Governments may be interested in taking over the project to prevent the Mediterranean fruit fly infestation of citrus orchards and other fruit crops in their countries. A similar project has been carried out on a much smaller scale in Capri and Procida in Italy.

A meeting in May 1968 in Vienna reviewed progress in the use of this technique in general and its possible extension to other insects. The Agency and FAO have, therefore, started co-ordinated research projects to study application of the technique to the rice stem borer and to Heliothis insects (the corn, tomato and cotton worm complex). A new branch of the Agency's laboratory at Seibersdorf for mass rearing of insects is doing work on the Mediterranean fruit fly, the olive fly, the tsetse fly and the codling moth.

domestic animals

Currently, the most promising nuclear technique in animal husbandry is to use radiation to produce vaccines against helminthic diseases (e.g. internal parasites). The co-ordinated research programme in Czechoslovakia, Denmark, Israel, Italy, Kenya, UK, USA and Yugoslavia has achieved the following results: a practicable method for control of the sheep lungworm and promising leads for the production of vaccines against several other helminthic organisms.

The Agency has also launched studies in Argentina, Austria, Denmark, Federal Republic of Germany, the Netherlands, UK, USA and Yugoslavia on using radioisotopes in research in anaemic diseases and mineral metabolism in livestock.

protection against contamination

In all parts of the world vast amounts of chemical insecticides such as DDT are being used by farmers to spray crops. The residues left on the crops are a growing danger to public health. Radioisotopes provide the most efficient techniques that can be used to study the effects of such residues on man and on livestock. The Agency and FAO are now developing a co-ordinated research programme to study the fate of pesticide residues in the food chain and to detect minute but harmful quantities.

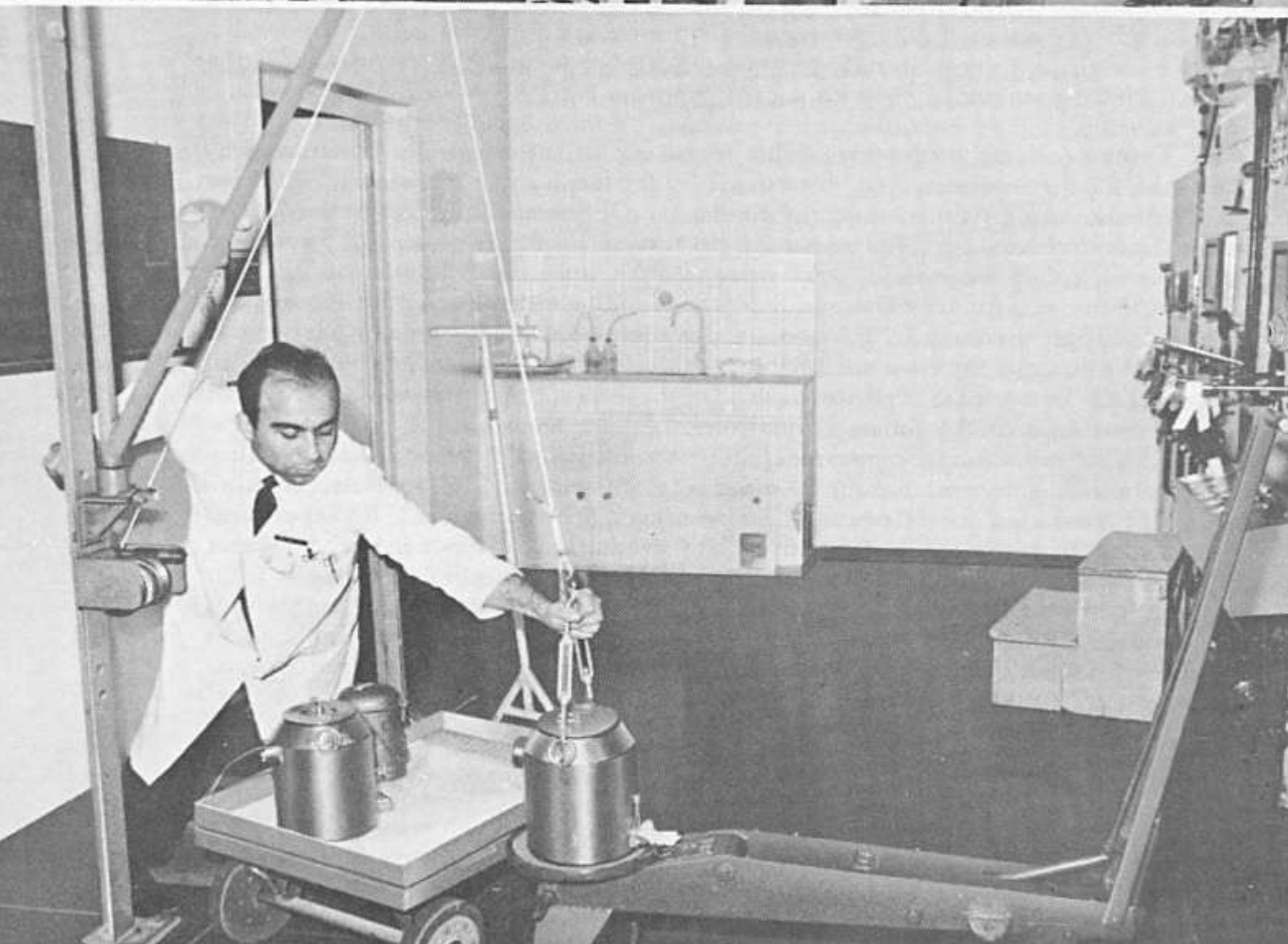
food conservation

Radiation can be used:

- to disinfest (that is, to kill insects) in stored grains and dried fruits;
- to pasteurize or sterilize;
- to prolong the shelf life of fresh meat, fish, fruit and vegetables;
- to slow down ripening and sprouting.

Extensive long-range tests must be made to satisfy public health authorities that radiation-preserved foods are safe for human consumption. The authorities in some countries (e.g. Canada, Israel, Soviet Union and the United States) have cleared certain radiation-preserved foods (e.g. wheat, potatoes, onions and other vegetables and dried fruits), but much has to be done to secure a wider acceptance. Use and acceptance of the technique could be important for food grown in developing countries and valuable to their export trade.

FAO and the Agency are setting up a clearing house for wholesomeness data to help provide a uniform legislative basis for irradiated food. This will assist countries to make full use of wholesomeness tests carried out in the few major food irradiation programmes. The Agency and ENEA are also taking steps to launch an internationally financed testing facility to make wholesomeness studies of irradiated foods of major importance. The Agency and FAO are also co-operating in a project in Iceland on the irradiation of fresh fish and lobster to study the possibilities of lengthening shelf life. A number of trainees from developing countries are taking part in this. A study group on food irradiation was held in Bulgaria in June 1968, especially for scientists from the Balkan countries. A visiting seminar toured South East Asia to advise on food irradiation research now being carried out by several countries in the area.



for better health

The first practical use of nuclear techniques, for many developing countries, is in medicine. These techniques are used:

— to diagnose and treat certain diseases, such as cancer or diseases of the thyroid (e.g. goitre, which is endemic in many developing countries);
— to study biological processes and the effects of specific diseases. Nuclear science techniques are unique in two ways. They provide a moving picture of biological processes within the human body and they permit the chemical analysis of minute quantities of biologically significant materials;
— to follow the life cycle of the vectors (carriers) of certain diseases. This gives important information about ways of controlling insects and other disease-carrying organisms.

Generally speaking, the Agency concentrates on new techniques and applications while WHO takes over when a technique has become an established part of the medical doctor's armoury.

The number of medical radioisotope laboratories in developing countries is increasing and there are now 283 high-energy radiotherapy centres among them. The Agency's programme focusses especially on:

— supporting research on anaemia, endemic goitre, malnutrition, parasitic infections (e.g. bilharzia) and other diseases endemic in developing countries;
— developing and standardizing radioisotope techniques;
— laboratory services for WHO programmes.

Some examples of this work during the past year are:

— Training courses in Bucarest and in Moscow on medical application of radioisotopes. The participating doctors came from developing countries in Africa, Asia, Europe and Latin America.
— A new research contract programme in collaboration with WHO to develop radioisotope techniques of special interest to the developing countries (e.g. whole body counting techniques and their applications in nutritional studies).

▲ *Injecting a small amount of radioactive "tracer" into the bloodstream of a Thai patient to diagnose an ailment. IAEA experts have helped with this technique.*

◀ *Greece is now preparing some radioisotopes of its own for medical use, helped by an IAEA expert. Photo: IAEA/Moir*

- An international symposium attended by more than 400 participants in Salzburg, Austria, on scintigraphic methods used with radioisotopes enabling a precise picture to be made of tumours and other disturbances within the body.
- A meeting in Teheran on radioactivation techniques for the study of mineral elements metabolism in man. This led to a number of research projects on the metabolism of trace elements of importance to several diseases prevalent in the developing countries.
- A meeting in Caracas on the requirements of radiotherapy centres in Latin America for facilities to measure radiation dose. Largely as a result of this meeting, WHO is establishing a regional dosimetric centre in Buenos Aires, with the help of IAEA.
- A new distribution service of standards which enables radiological institutes to compare and check the radiation doses given by the equipment they use.

isotopes save money

Radiation and radioisotope devices are standard equipment in modern industry. More than a thousand applications are known. Their use saves hundreds of millions of dollars each year in running costs and is helping industry to make new and better products. The Agency's programme concentrates on helping developing countries to introduce these techniques in selected industries. The following are some examples of work done during the last year:

— An international symposium in Buenos Aires in November 1968. This reviewed the use of nuclear techniques in the mining industry, where they are now employed in all stages from prospecting and the discovery of new mineral resources to production and refining. The symposium was attended by mining engineers and nuclear technologists from 20 countries.

— A new technique in natural resources development is the use of radioisotope X-ray fluorescence to carry out rapid, on-the-spot analyses of the mineral content of ores. A meeting of specialists assessed the technical and economic potential of this technique, which is being used in several technical assistance projects (e.g. in India, the Philippines, Yugoslavia).

— The use of radiation to improve the qualities of woods and fibres is growing. For example, soft woods can be made hard by the irradiation of wood-plastic composites. In 1967, the Agency began to co-ordinate research on similar treatment for fibrous materials, particularly bagasse board, which is made from sugar cane and which can be improved to make it suitable for construction purposes. During 1968-69 this programme was expanded in Asia and the Far East.

◀ *Carved by a Chinese craftsman, these are the first "atomic statues", having been soaked in chemicals and then irradiated. This method may bring great savings for a useful export industry by reducing breakages in transport. Photo: IAEA/Arzensek*

the nuclear divining rod

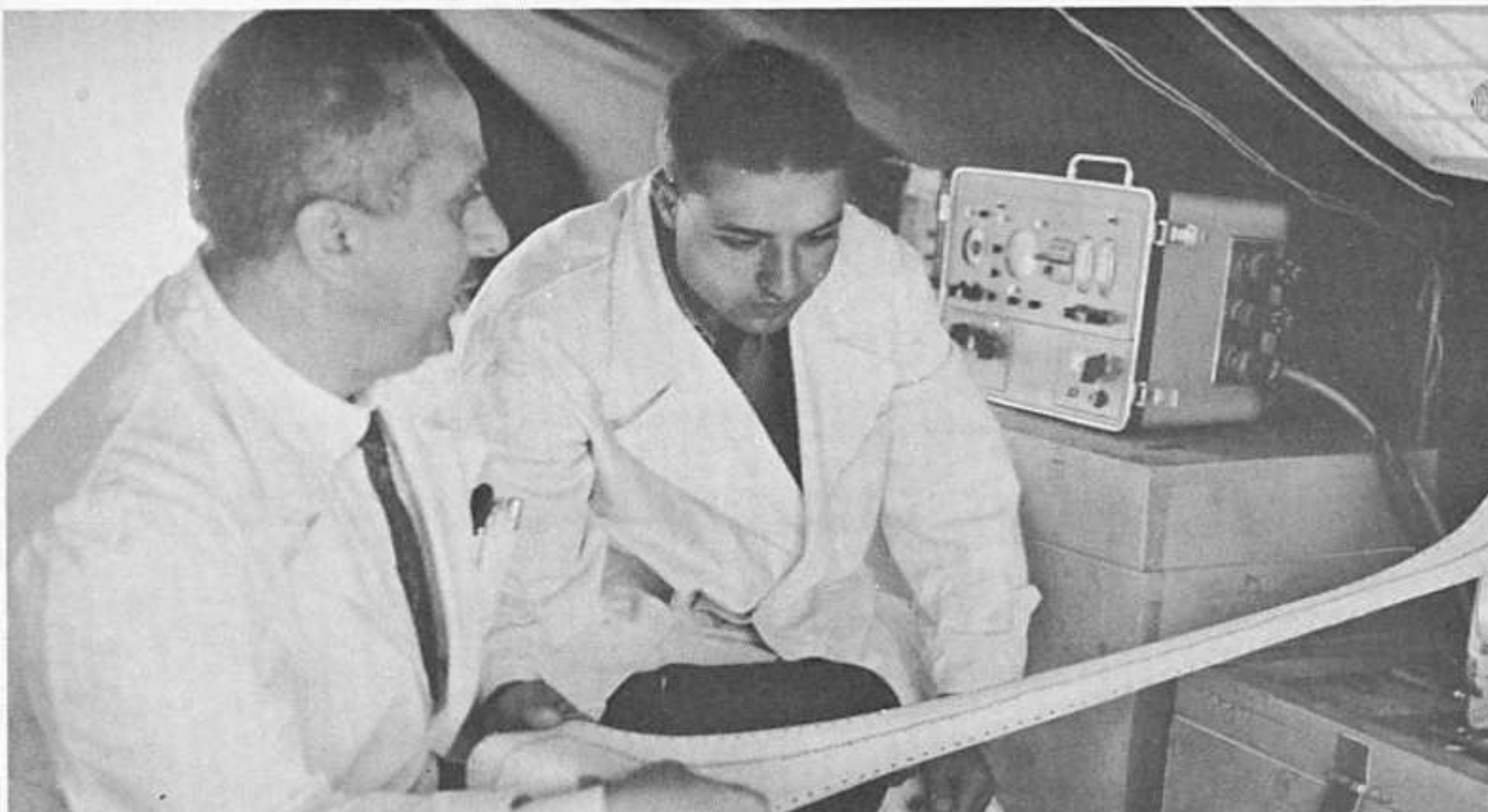
Investigation of water resources provides a good example of the use of nuclear science techniques in applied research. Isotopes from the atmosphere can give information about the history and movement of water, which is of vital importance in studying the hydrology of countries and regions. Artificial radioisotopes can be used to follow and measure water movements beneath the ground. Nuclear instruments are used to measure the water content of snow and of soils and the amount of sediments carried by rivers. The potential applications of these techniques in developing countries are numerous.

The Agency has made arrangements with FAO, UNESCO, WHO and the United Nations itself to use these techniques in suitable water resource exploitation projects. As a result, the Agency is now providing isotope services as a subcontractor to UNDP Special Fund projects in: Algeria, Chad, Dahomey, Jordan, Niger, Senegal and Spain.

During the year, the IAEA also sent advisory missions to Greece, India, Saudi Arabia, Indonesia, the Philippines and Singapore to identify problems where isotope techniques can be used.

Technical assistance experts were sent to Brazil, Chile, India and Mexico.

The Agency continues to support special studies of water resources in China, Hungary, Pakistan, Romania and Turkey, as well as in some advanced countries. This field work is supported in a series of meetings to review the latest developments, to prepare guidebooks (e.g. in 1968 the Agency published a "Guidebook on Nuclear Techniques in Hydrology") and by work at the IAEA's own laboratory in which, during the year, scientists from Kenya and Turkey were trained in the use of isotope techniques.



sharing new knowledge

About 100 000 articles are now being published each year to report new information on nuclear science and its peaceful applications. Seven technically advanced countries account for 80% of the information that is generated. However, all countries with atomic energy programmes have an interest in this material, and, in various degrees, have set up information services to process it and to retail it to individual scientists and engineers. The technically advanced countries are turning increasingly to sophisticated techniques, particularly computers for information analysis and microfiches for information storage.

The Agency's programme is designed:

- to give all Member States access to this wealth of information;
- to foster the exchange of ideas, before they reach the printed word, between scientists from different countries;
- to help developing countries to take a full part in this information exchange.

To this end the Agency:

- holds about 12 major scientific symposia a year on topics covering the full range of nuclear science and technology. Although the main interest in these symposia comes from technically advanced countries, the Agency is now helping to pay attendance costs at each symposia of scientists from selected developing countries.
- holds about 30 to 40 smaller meetings each year. Many of these help to guide and direct the Agency's own programmes. For instance, scientists doing research in developing countries under the IAEA's co-ordinated programmes are brought together regularly to review progress and plan ahead. Other meetings are specially aimed at helping the scientists from a particular developing region to learn about the latest advances in a particular branch of technology — for instance, how to manage radioactive wastes — and to launch co-operative projects in the region.
- publishes about 30 000 pages of scientific information each year.
- maintains a library of books, reports, periodicals and films whose services are available to Member States. In particular there is a service by which any Member State can get microfiche copies of any item in the Agency's library at a reasonable charge.

◀ *In the Great Sahara tritium is used for water studies by scientists of the Middle Eastern Regional Radioisotope Centre for the Arab Countries. Here two of them are taking measurements from a borehole. Photo: IAEA / Goldberger*

In 1970, the Agency will launch an International Nuclear Information System (INIS), aimed at giving each Member State access to new information published throughout the world in all branches of nuclear science. Thus, the individual research worker will be able to know what is being done in his particular subject in all other laboratories and countries co-operating in the system.

For INIS, each country will report to the Agency on all the nuclear literature it is publishing. This means that the amount of work expected of each country is roughly in proportion to the size of its nuclear programme. Countries with computer facilities will send in the information in machine-readable form. Others will do so on standard work-sheets which the Agency will transfer to magnetic tape. The Agency will arrange training programmes to help documentalists in different Member States to follow consistent standards.

The Agency will merge all information received into a comprehensive "bank". Copies of this bank will be distributed on magnetic tape or microfiche to participating countries. It is expected that many countries will use such copies as the basis for providing national nuclear information services. To help developing countries that lack computing facilities, INIS will print out the contents of each magnetic tape and will publish, twice a month, a list of all new articles that have been reported. At a later stage, it is expected that the Agency will offer a direct information retrieval service for individual scientists in developing countries.

a world centre for theoretical physics

In 1964 the Agency, with help from the Italian Government and the City and University of Trieste, established an International Centre for Theoretical Physics in Trieste.

Within a short time the Centre's seminars, courses and schools have attracted visits from most of the leading theoretical physicists from all over the world. Scientists from developing and technically advanced countries, from East and from West, have worked together in preparing hundreds of contributions to man's knowledge and concepts of theoretical and experimental physics, the scientific disciplines upon which nuclear science and technology are based. UNESCO and the Ford Foundation have made special grants or fellowships to enable the Centre to expand its work.

helping to stop the brain drain?

The Trieste Centre is testing a technique for reducing intellectual isolation and the "brain drain" which is costing the developing countries some of their best scientific talent. Besides the 25 or so fellowships awarded each year, the Centre has evolved schemes of associateships and of affiliations. These enable leading physicists from the developing countries to spend one to three months each year at the Centre, at times of their own choice, working with their colleagues from all parts of the world and returning to their home universities or institutes for the remainder of the year.

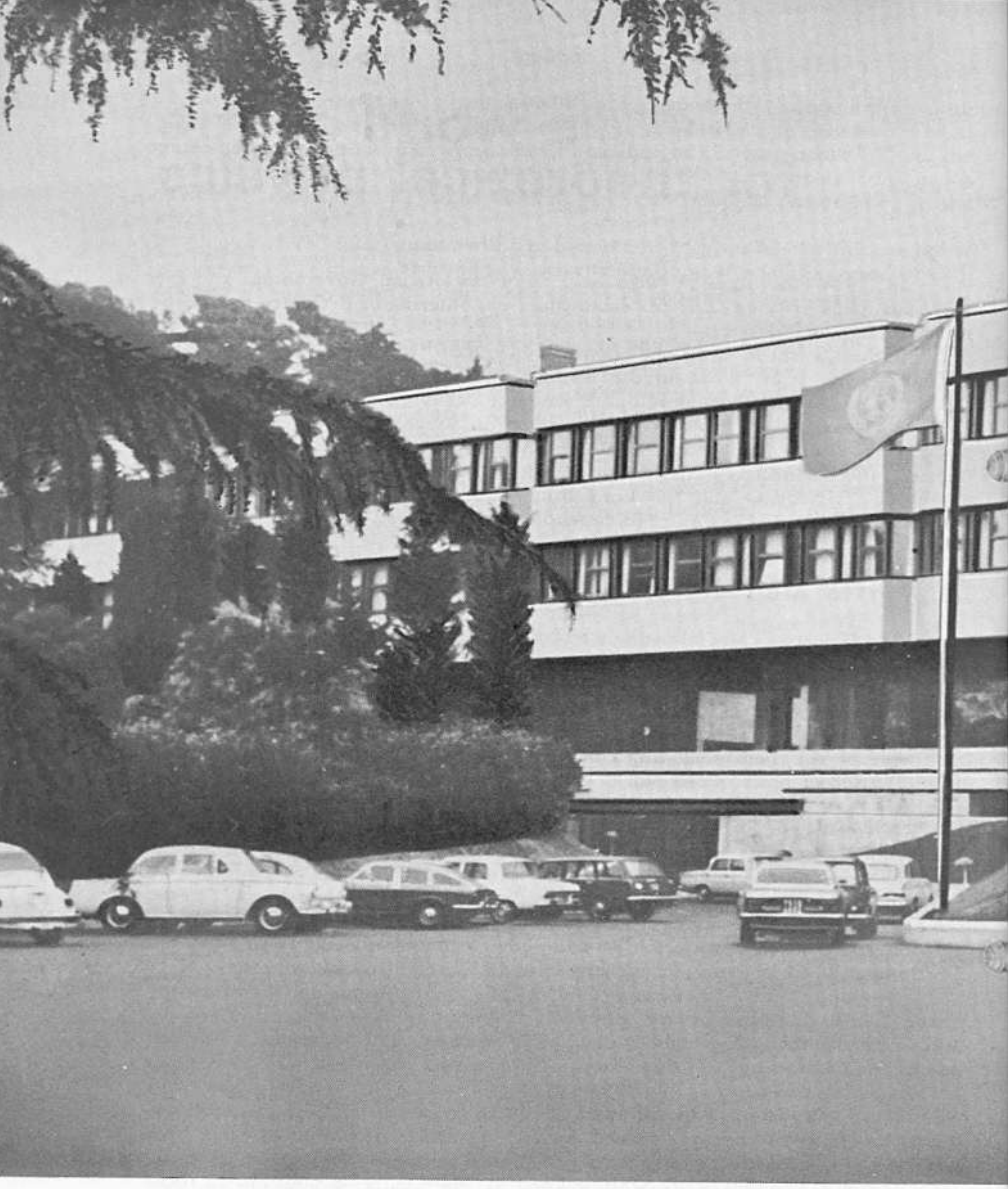
A small core of permanent international staff helps the associates, fellows and visiting scientists in research activities. Senior scientists from all groups give lectures and hold seminars for their more junior colleagues. To help students to reach the level needed by the Centre the University of Trieste, UNESCO and IAEA also sponsor a school for theoretical physics.

A total of 85 associateships and fellowships have been awarded at the Centre to date, 12 of them in the twelve months covered by this report.

In June 1968 the Centre held a four-week symposium to review the whole field of contemporary physics. The symposium was attended by 300 scientists including eight Nobel prize winners, and represented the first international meeting of this kind. Seventy-two scientists attended from 21 developing countries.

The symposium was followed in 1969 by a three-month international course on modern theory attended by 187 physicists of whom 78 came from 24 developing countries.

Among 178 physicists who worked at the Centre in addition to those mentioned above, 92 from 26 developing countries accounted for 281 of 441 man-months. The number of Federated Institutes has been increased to 19, of which all but three are in developing countries.



▲ *Opened in 1968. The new headquarters of the International Centre for Theoretical Physics, built by the Italian Government. Photo: Rice, Trieste*

stepping stones to the future

This report has shown how much is expected from nuclear science and technology: cheap and abundant power, fresh water, larger crops of a higher quality, new methods for industry, large-scale civil engineering, tools for the doctor and the scientist.

Nuclear technology is still young. It is certain that wider and as yet unknown applications will emerge. To quicken the pace of development, co-operation is essential. Even the largest industrial nation cannot in isolation make the same progress as it can in a world community where information is freely exchanged and efforts combined. The door to the nuclear future would have been virtually closed to the developing world were it not for international co-operation. The IAEA's means are small compared with the large sums now being invested in nuclear technology. By working together, however, through IAEA its 101 Member States evolve co-operative ventures far greater than the sum total of the efforts they invest.

Another basic function of the Agency — to guard against the military use of nuclear materials and facilities — not only serves the cause of peace but also helps to conserve and to stimulate national and international efforts for the constructive uses of nuclear technology. A further spread of the nuclear arms race would withdraw additional resources from the development of peaceful applications and thereby nullify the promise of atomic energy, above all for the developing countries.

At its 1968 session, the IAEA General Conference endorsed a programme that will guide the Agency's work during the next six years. Continuing technical assistance and training, promotion of research and development, fostering of world-wide co-operation, speeding the flow of information and safeguarding of nuclear materials are the main themes.

Since 1957 the IAEA has gained useful experience of the problems of introducing and spreading nuclear technology, as well as of the possibilities for development in Member States and regions. It has evolved its procedures for technical co-operation. It has achieved a valuable concentration of scientific and technical ability. With little increment in its manpower much larger funds and other resources could be channelled through it to developing countries.

When the IAEA was founded, the first General Conference unanimously agreed that its "potential as an investment in the orderly future development of the greatest natural force known to man, is incalculable". The time has come when this potential should be fully exploited.

the membership of iaea

Membership of the Agency, at the time this report was going to Press, consisted of 102 nations.

The full list is:

AFGHANISTAN
ALBANIA
ALGERIA
ARGENTINA
AUSTRALIA
AUSTRIA
BELGIUM
BOLIVIA
BRAZIL
BULGARIA
BURMA
BYELORUSSIAN SOVIET SOCIALIST REPUBLIC
CAMBODIA
CAMEROON
CANADA
CEYLON
CHILE
CHINA
COLOMBIA
CONGO, DEMOCRATIC REPUBLIC OF
COSTA RICA
CUBA
CYPRUS
CZECHOSLOVAK SOCIALIST REPUBLIC
DENMARK
DOMINICAN REPUBLIC
ECUADOR
EL SALVADOR
ETHIOPIA
FINLAND
FRANCE
GABON
GERMANY, FEDERAL REPUBLIC OF
GHANA
GREECE
GUATEMALA
HAITI
HOLY SEE
HUNGARY
ICELAND
INDIA
INDONESIA
IRAN
IRAQ
ISRAEL
ITALY
IVORY COAST
JAMAICA
JAPAN
JORDAN
KENYA
KOREA, REPUBLIC OF
KUWAIT
LEBANON
LIBERIA
LIBYA
LIECHTENSTEIN
LUXEMBOURG
MADAGASCAR
MALAYSIA
MALI
MEXICO
MONACO
MOROCCO
NETHERLANDS
NEW ZEALAND
NICARAGUA
NIGER
NIGERIA
NORWAY
PAKISTAN
PANAMA
PARAGUAY
PERU
PHILIPPINES
POLAND
PORTUGAL
ROMANIA
SAUDI ARABIA
SENEGAL
SIERRA LEONE
SINGAPORE
SOUTH AFRICA
SPAIN
SUDAN
SWEDEN
SWITZERLAND
SYRIAN ARAB REPUBLIC
THAILAND
TUNISIA
TURKEY
UGANDA
UKRAINIAN SOVIET SOCIALIST REPUBLIC
UNION OF SOVIET SOCIALIST REPUBLICS
UNITED ARAB REPUBLIC
UNITED KINGDOM OF GREAT BRITAIN AND NORTHERN IRELAND
UNITED STATES OF AMERICA
URUGUAY
VENEZUELA
VIET-NAM
YUGOSLAVIA
ZAMBIA

voluntary contributions

Details of the contributions by Member States to the Agency's General Fund for 1968 and 1969 are (in US dollar equivalent):

	1968 (Paid)	1969 (Pledged)
Argentina	16,600	16,800
Australia	23,352	28,400
Austria	9,600	10,400
Belgium	10,000	—
Brazil	17,000	16,200
Bulgaria	2,500	3,200
Burma	1,000	1,000
Canada	57,000	57,000
Ceylon	2,100	2,100
China	—	10,000
Colombia	2,000	2,000
Congo, Democratic Republic of	1,000	1,000
Cyprus	800	800
Czechoslovak Socialist Republic	20,833	20,833
Denmark	11,200	11,200
Finland	12,000	9,000
France	30,612	—
Germany, Federal Republic of	133,400	127,400
Ghana	1,400	1,800
Greece	4,400	5,200
Holy See	2,000	2,000
Hungary	3,333	6,667
Iceland	800	800
India	35,000	35,000
Indonesia	3,000	6,200
Iran	2,000	3,600
Iraq	1,400	1,400
Israel	3,000	3,600
Ivory Coast	803	800
Japan	49,800	60,000
Korea, Republic of	2,400	2,200
Kuweit	1,000	3,000
Lebanon	1,000	—
Madagascar	800	800
Mexico	—	14,700

voluntary contributions

	1968 (Paid)	1969 (Pledged)
Monaco	2,000	2,000
Morocco	2,000	—
Netherlands	20,000	21,000
New Zealand	6,800	—
Norway	8,000	7,800
Pakistan	6,000	6,000
Philippines	6,200	6,200
Poland	6,250	6,250
Portugal	3,600	3,600
Romania	6,200	6,200
Saudi Arabia	1,200	1,200
Singapore	800	1,000
South Africa	9,400	9,400
Spain	10,000	10,000
Sweden	22,600	22,800
Switzerland	15,800	15,600
Thailand	3,000	3,000
Turkey	6,200	6,400
Uganda	—	1,000
Union of Soviet Socialist Republics	111,111	166,667
United Arab Republic	11,500	11,500
United Kingdom of Great Britain and Northern Ireland	110,000	110,000
Uruguay	—	2,000
Venezuela	—	8,200
Viet-Nam	1,400	1,200
Yugoslavia	8,000	8,000
	839,194	902,117
United States of America (including matching contribution)	440,151	434,353
TOTAL	1,279,345	1,336,470

The USA pledge for 1969 is equivalent to 32,5% of the total pledged by all Member States.

addendum
to the agency's report
to the economic
and social council of the
united nations
for 1968-69
(INFCIRC/126)

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