the fourth geneva conference

The Fourth International Conference on the Peaceful Uses of Atomic Energy took place in Geneva from 6 to 16 September. Convened by the Secretary General of the United Nations, with the assistance of the UN Scientific Advisory Committee, in co-operation with the International Atomic Energy Agency and in consultation with interested specialized agencies of the UN, the Conference paid particular attention to the interests of public officials, economists and planners as well as technologists. This article reviews main points made by speakers at the opening of the Conference, and the summing-up at the end. The full proceedings of the Conference will be published in a few months.

The agenda for the Conference covered nuclear power and special applications, nuclear fuels, fuel cycles and materials, health, safety and legal aspects of the use of nuclear energy, applications of isotopes and radiation, international and administrative aspects of the use of nuclear energy, and aspects of nuclear technology of particular interest for developing countries.

During 10 general and 51 technical sessions 514 papers were presented; in addition, there were two discussion panels. The Conference was attended by about 1 800 delegates and advisers representing 79 countries and several UN agencies, together with more than 2000 observers.

The Conference reviewed the performance of existing nuclear power plants and their fuels, and surveyed world energy demands and resources up to the year 2000 and the rôle nuclear energy is expected to play in meeting those demands. Emphasis was placed on the safety aspects and costing of nuclear power plants, on their integration into electrical supply networks and on the impact of such plants on the environment. Another major theme of the Conference was the overall effect of the introduction of nuclear power in developing countries; so, too, was the application of isotopes and radiation in these areas. Much interest focussed on the

development of the fast breeder reactor, which may well represent a solution to the problem of making full use of world uranium resources and, looking even further ahead, several papers dealt with the status and prospects of controlled thermonuclear reactions — that is, the promise of obtaining power from fusion.

The health, safety and legal aspects of the use of nuclear energy were covered in several technical sessions and, when the Conference considered the international and administrative aspects of the use of nuclear energy, particular attention was given to the problems of safeguarding nuclear materials against their diversion from intended peaceful uses.

In the two general discussion panels, distinguished scientists discussed and answered questions about the ecological aspects and public acceptance of nuclear energy; and the introduction of nuclear power into developing countries.

During the Conference a governmental scientific exhibition in which 19 countries took part, with the theme "Atoms for Development", was held at the Palais des Expositions; and an exhibit depicting aspects of the work of the IAEA was mounted at the Palais des Nations, the venue of the Conference itself.

The value of the Conference

The Conference was opened formally by Dr. Glenn T. Seaborg, outgoing chairman of the United States Atomic Energy Commission, who served as President. Introductory speeches were made by, among others, Mr. Philippe de Seynes, United Nations Under-Secretary General for Economic and Social Affairs, on behalf of the Secretary General, U Thant; Dr. Seaborg; Dr. Sigvard Eklund, Director General of the IAEA; and Professor I. I. Rabi, a Vice-President of the Conference and a member of the UN Scientific Advisory Committee.

Mr. de Seynes said meetings such as the Geneva Conference were very valuable in breaking down the artificial restrictions that prevented the free exchange of information between scientists — an objective that had been largely achieved: that of accelerating the transfer of scientific and technical knowledge to the developing countries had not.

He referred to the immense value of the work of the United Nations in trying to control the adverse effects of atomic energy — with respect to treaties relating to the prohibition of nuclear weapons and agreements on safeguards linked with the growth and spread of nuclear power. But these achievements "do not mean that all is well, and I regret that weapons testing continues. I sincerely hope that an agreement on a complete test ban will be reached in the near future in the Conference of the Committee on Disarmament at present meeting in Geneva." Nuclear energy properly safeguarded and safely used could bring untold benefits to mankind; the responsibility for its advancement, its safeguarding and its safe use would rest to a considerable extent with those attending the Fourth Geneva Conference.

Dr. Seaborg, in his opening address, reviewed the three previous Geneva Conferences, held in 1955, 1958 and 1964. At the first, he recalled, the late Dr. Homi Bhabha prophesied correctly that nuclear energy would be of importance not only to the industrialized nations but to developing countries as well. However, the second Conference,

presided over by the French physicist Francis Perrin, was rather "an occasion of comparative pessimism" since Dr. Perrin foresaw that at first nuclear energy would be principally useful in the highly industrialized countries. That phase was now drawing to an end: by 1980 nuclear power plants were likely to be in operation in 15 countries currently considered to be developing. Moreover, the first two Conferences had been especially important in that they removed the veils of secrecy from nuclear energy and opened up new channels of communication.

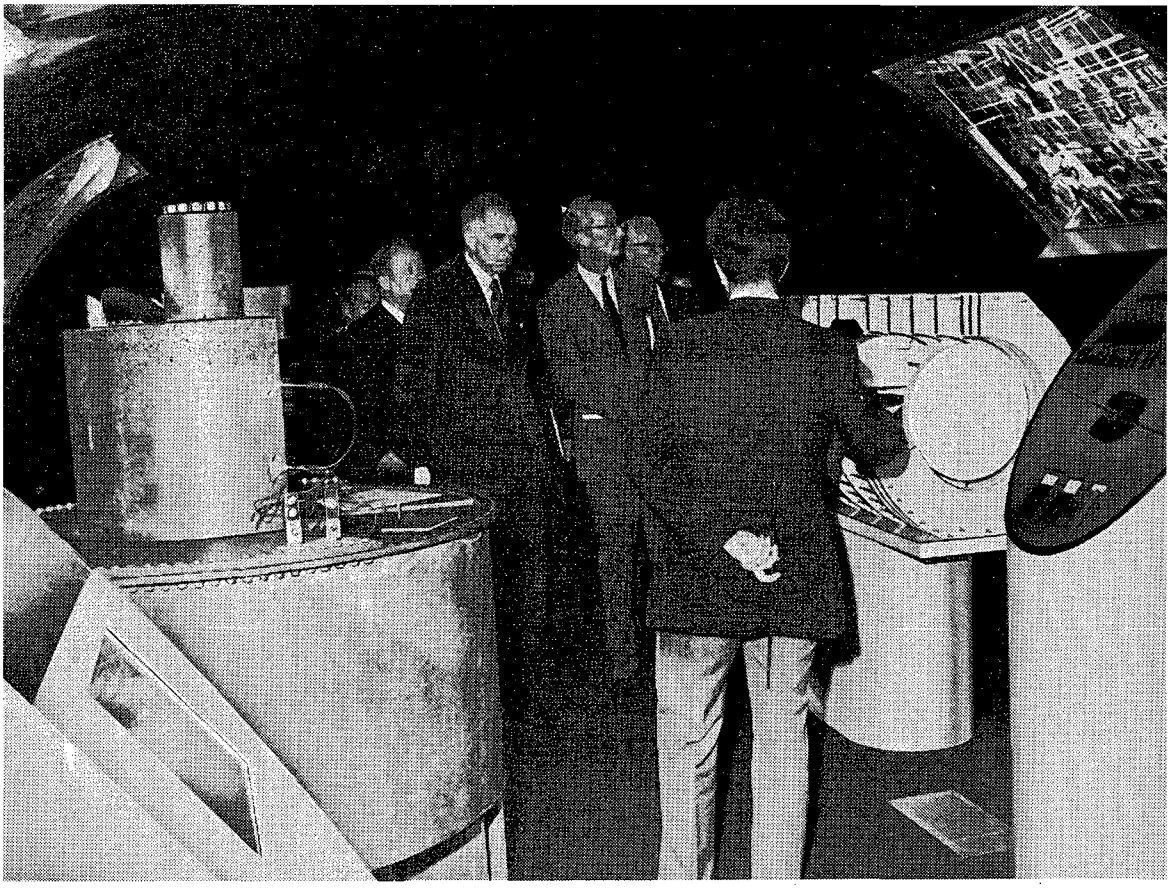
"The Third Geneva Conference," he went on, "was an historic landmark." It marked clearly the beginning of an era of economic nuclear power. With more than 150 million kilowatts of nuclear capacity now in operation, under construction or on order in the world today, there was no doubt that an "economic breakthrough" had been achieved in nuclear power technology. Dr. Seaborg emphasized that in nuclear science progress did not "just happen", but was reached as a result of deliberate decisions and actions of governments and scientists. The great remaining tasks for nuclear technology were to unlock the energy resources of uranium-238 and thorium-232 by perfecting an economic breeder reactor; to use the unparalleled opportunity of nuclear power to stop environmental pollution by conventional fuels and combustion products; to study plasmas and their behaviour with the intention of exploiting them as a source of electric power; and to extend the application of radioisotopes, especially in medicine and agriculture.

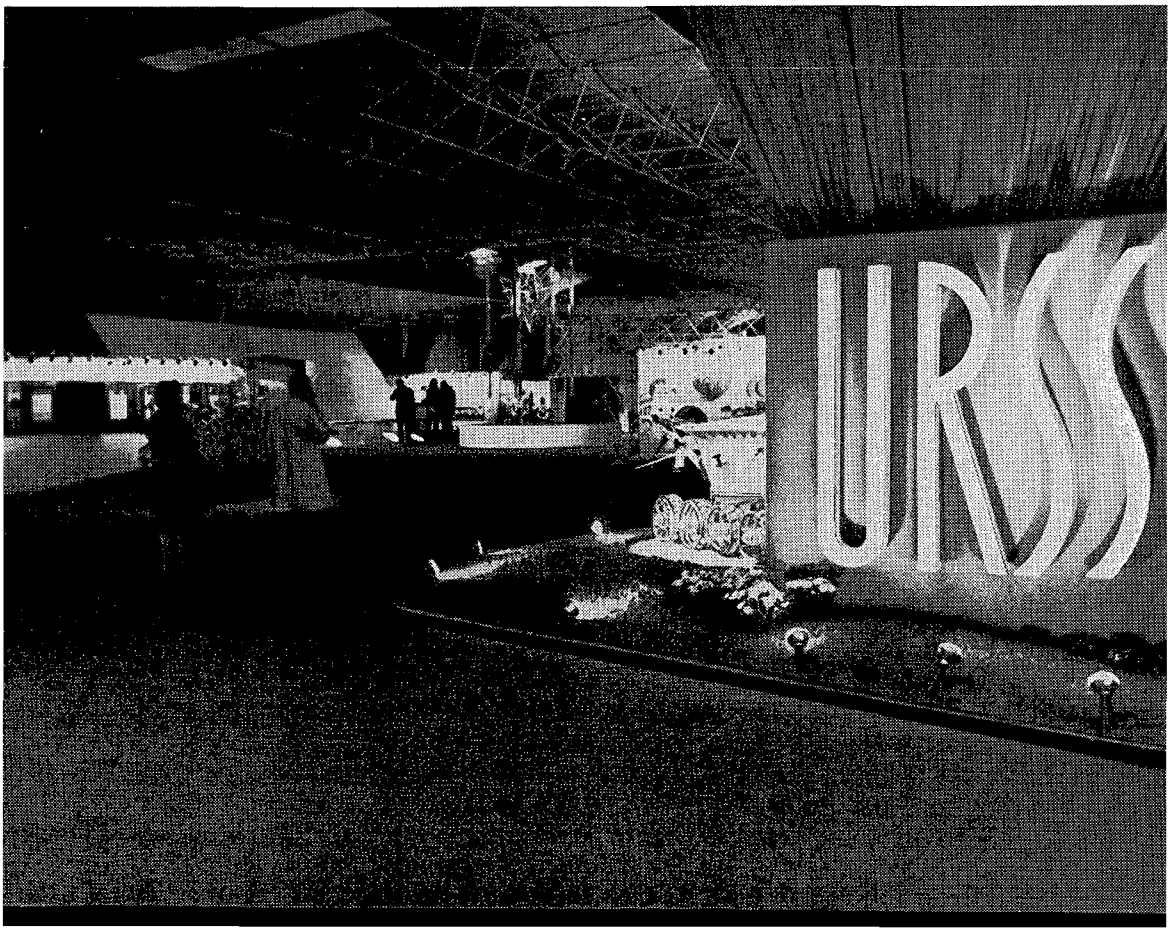
From the earth to Mars?

As for the future, Dr. Seaborg said he believed that through the use of nuclear propulsion the outer planets such as Jupiter would surely be examined instrumentally this century, and that man was likely to visit Mars by the same means. "Giant earth-stationary satellites bearing compact nuclear reactors will broadcast TV programmes and other messages directly to home receivers," he declared. "Nuclear-powered tankers and other nuclear merchant ships will almost certainly ply the seas. Peaceful nuclear explosives will be employed on a widespread scale to improve the recovery of underground natural resources, and possibly to modify topography in such ways as the building of harbours, canals and reservoirs." He believed, too, that there would be international agreements to assure the safe transport of radioactive materials and their safe disposal. Nuclear trade would become essentially conventional in nature, subject only to the requirement that its peaceful purpose be assured by appropriate safeguards arrangements. International co-operation would continue to flourish, but would become less a concern of governments and more a direct activity of scientists and industry. On the frontier of nuclear science, larger accelerators would be built under international auspices.

Members of the official party at the inauguration of exhibit of the United States, in the Palais des Expositions. Photo: UN

A general view of the USSR exhibit. Photo: UN

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The growing rôle of nuclear power

Dr. Eklund, in his address, reminded delegates that nuclear power accounted at present for about 2 per cent of installed electrical generating capacity; by 1980 it was expected to reach 13 per cent and by the turn of the century some 50 per cent.

The problems faced now related to practical questions of operating installed plants, integrating the nuclear industry into national economies, securing adequate supplies of nuclear fuel, removing trade barriers and demonstrating to the consumer that the use of nuclear power would have no detrimental effect on the environment.

Since nuclear energy had now come of age, he said, nuclear materials were of strategic importance. It was vital to take international steps now toward their regulation and control. Nuclear fuels, especially when irradiated, had to be handled as potentially hazardous substances, requiring special attention when they were transported across national frontiers.

The growth of nuclear power depended largely on the supply of uranium and, moreover, of uranium enrichment. Therefore the European Nuclear Energy Agency (ENEA) and the IAEA jointly conducted periodic surveys of world uranium and thorium reserves and concluded that considerably more uranium must be found in the 1980s to meet growing demand. The IAEA was also following closely the development of new enrichment facilities.

As for environmental questions, things should be put into the right perspective: "As a matter of fact, if we do not consider hydro-power, which leads to special environmental problems, nuclear power is the cleanest means of producing electricity."

Dr. Eklund declared that the Treaty on the Non-Proliferation of Nuclear Weapons, which came into force on 5 March 1970, should have — if properly implemented — as great an impact on the peaceful development of nuclear energy as on the control of nuclear weapons. "The Agency was designated as the control organ of the Treaty, whereby non-nuclear-weapon States agree to accept Agency safeguards in order to verify the fulfillment of their obligations... The Agency is now in the process of negotiating safeguards agreements with non-nuclear-weapon States Party to the Treaty." So far, the Treaty had been signed by 98 non-nuclear-weapon States, 66 of which had ratified it.

Nuclear energy and mankind

Professor Rabi took as his subject the way in which the development of atomic energy affected mankind. Although far from mature, atomic energy was nevertheless no longer in its infancy; it was very big business, both private and governmental. Its applications led into almost every important activity in industry, in science, in health, in archeology and even in astronomy.

"The population explosion, coupled with a desire for a so-called higher standard of living, puts enormous stresses on the environment...The exhaustion of mineral resources and raw materials like coal, gas and oil keeps on occurring in euphoric haste. We proceed blindly in the faith that science will find a solution to the problems of diminishing natural resources."

Prof. Rabi said human populations were now so dense and widespread that soon no other sites for exploitation would be available. "We must remember that the elimination of many species of life, through human action or neglect, may be only the prelude for the elimination of mankind itself."

Of "the most immediate danger of all, nuclear warfare," Prof. Rabi said "this senseless threat to human culture and indeed to human survival has no precedent in history... We can hope that if indeed we survive to the future, men will realise deeply that their most noble goal is to understand themselves within the universe, and that this goal will override all the petty and parochial aims that so disturb the peace and endanger mankind's future existence."

The summing-up

At the close of the Conference Professor Nikolai Bogolubov, Member of the USSR Academy of Sciences, introduced his summing up of the work of the Conference by saying that although he undertook this task as objectively as he could, as a scientist he felt able to deal only with what he considered were the most fundamental achievements that had been reported.

There was no doubt, he said, that the exchange of scientific and technical ideas that had taken place, and the demonstration of the achievements gained in various countries, would have a very considerable effect on the further development of atomic science and engineering.

"Over the seven years that have passed since the Third Geneva Conference there has been intensive development of atomic science and engineering in virtually all countries of the world... Analysing the papers presented by scientists and experts from many countries, we can say with confidence that the Fourth Geneva Conference has demonstrated that the practical utilization of nuclear energy is developing by leaps and bounds.

"Whereas before the First Geneva Conference in 1955 nuclear power production was represented by one single atomic power station (the Obninsk Atomic Power Station with a capacity of 5 MW), before the Fourth Conference the number of power reactors in operation or under construction had reached more than 230. According to data from the IAEA, by the end of April 1971, 102 reactors were in operation and 131 power reactors were at the construction stage.

"Achievements in nuclear technology and its use for peaceful purposes have attracted the attention not only of scientists and engineers, but also of statesmen.

"At the present time a large number of countries have five-year plans or long-term national programmes for the development of nuclear science and engineering. The existence of these national programmes, together with co-operation within the framework of the International Atomic Energy Agency and other specialized international organizations, makes it possible to solve the very important problems involved in utilizing nuclear energy in the way best suited to the purpose. A considerable contribution to the effective solution of utilizing nuclear energy for peaceful purposes has been made by the papers presented at this Conference and by the creative discussions that have been held here at the Palais

des Nations, at the Governmental Scientific Exhibition and in various places in Geneva."

In view of the international character of the work being done in relation to the peaceful application of nuclear energy, he did not wish to single out the part played by any one country. All achievements in this connection were a contribution to the common storehouse of international attainments.

The course of the Conference had confirmed the initial promise and made it clear that the set purpose had been achieved. The people participating in the Conference and the nature of the papers presented were an indication that nuclear energy continued to consolidate its position in a very wide variety of human activities and that the most important sphere of application — nuclear power production — had reached the stage of extensive development on a world-wide scale.

This spread of nuclear power production on a broad scale "brings into prominence a number of important problems that may have missed the attention of large number of people at an earlier stage," said Academician Bogolubov. "This relates first and foremost to the effect on the environment, the safety of the population, problems of burying radioactive waste, the operation of nuclear power stations within power networks, the selection of the optimum fuel cycle for various reactor types, and study of the strength of construction materials.

"A study of world demands for energy and energy resources shows that by the end of this century half of the total electric power produced in the world will be generated by nuclear power plans... It should be noted that according to the forecasts made here, nuclear power output may reach three million megawatts by the end of this century. Calculation of requirements shows that in 1980 the capacity of nuclear power stations will be approximately 300 000 MW(e), and that over the following 20 years the output of electrical power from nuclear power stations should increase by a factor of approximately eight to ten. It is an understatement to say that this is a highly complex and difficult problem requiring the participation of scientists, engineers and industrial planners of the whole world for its solution. It is a task that approaches the fantastic.

"But the solution of these problems has already been begun by the extensive introduction of thermal neutron power reactors and development of the engineering problems involved in fast reactors."

Thermal reactors had undergone a considerable period of study and had now been adopted in industry. Both successes and difficulties had been encountered in their operation; it was now clear that the difficulties had been overcome by and large, and that the experience gained had established the preconditions for the rapid development of nuclear power production that had now begun. A discussion of experience acquired in developing and operating these reactors was a very important topic that had been dealt with by the Conference.

Ensuring safety

The next group of scientific and technical questions which had been of considerable interest to participants was that of the safe operation of nuclear power stations. There were various aspects to this problem: the

proper construction of reactors and their cooling systems; making suitable allowance for natural factors and correct siting; the devising of special standards, rules and procedures for ensuring safety of operation; safety and quality control of power station equipment.

Careful and accurate solutions of these problems depended on the scale of deployment of these stations and on the need to locate them in thickly populated regions and to attract large numbers of additional people into this sphere, along with new construction and industrial undertakings of various kinds.

The Conference had also dealt with the development and construction of improved types of reactors, characterized by enhanced efficiency of the thermodynamic cycle or improved fuel cycle parameters. Within the same general context, attention had also been paid to high-temperature gas reactors, heavy-water reactors of various types, the graphite reactor with a boiling-water cooling system, molten salt reactors and dissociating-gas reactors.

Fast breeder reactors opened up the possibility of improved utilization of the source material resources of nuclear fuel for power generation. Maximum attention was being devoted in the advanced countries to the development of reactors of this type.

Experimental fast reactors had been in operation for several years in the United States, the Soviet Union, the United Kingdom and France. Such reactors were being built in Italy, Japan and the Federal Republic of Germany. They had already demonstrated operational stability and reliability and were providing experience for the design of commercial reactors. By now the general trend and basic features of these reactors had been established: sodium cooling, ceramic fuel in a stainless steel cladding, three-loop circuit with steam turbines. However, they still had a long way to go before all the technological problems involved in the construction of large commercial reactors could be solved and the task for the immediate future was the construction of prototypes.

Fast reactors and the fuel cycle

Large fast-neutron power reactors were in the final stages of construction and assembly in the Soviet Union, the United Kingdom and France. Designs had been completed in the Federal Republic of Germany and the United States for demonstration prototype reactors; other projects were in the developmental stage in Italy and Japan.

Intensive work was being carried on in many countries in connection with the testing of fuel elements and equipment. These questions, which were dealt with at the Conference, were the ones which characterized the situation with respect to mastery of breeder-reactor technology.

"The focal point in conquering the problems of fast reactors is shifting to the technological problems of achieving reliability in various types of equipment and control systems in actual conditions of operation," said Academician Bogolubov. "It may be expected that these problems will be successfully resolved in the next few years and that the period after 1980 will be the period for the construction of fast reactors for commercial use. This will mark the beginning of a new stage in power engineering — that of breeder reactors producing electric power and fuel for future development.

Academician Bogolubov, during his summing-up of the Conference. The President of the Conference, Dr. Glenn T. Seaborg, is seated behind him. Photo: UN

"The rapid development of atomic power generation of course requires the corresponding development of all links in the fuel cycle. It is unnecessary to dwell on the importance of ensuring the supply of fuel. According to an estimate given in one of the review papers, the proven reserves of ore from which uranium can be extracted at a cost of up to $10 a pound amounts to approximately 1 million tons. This quantity is sufficient to satisfy uranium requirements only until the end of the 1970s. In this connection, stress has been laid during the Conference on the importance of increasing throughout the world prospecting for new uranium deposits and also the importance of improving methods of processing ore, particularly low-grade varieties.

"It seems to me personally that it is impossible to over-estimate the importance of developing new methods for the production of nuclear fuel by all possible means, including the extraction of uranium from seawater, bearing in mind the fact that uranium is present in the sea in quantities of the order of 4000 million tons."

As in most commissioned and planned reactors use was made of enriched uranium, it was quite logical that during the Conference great interest had been shown in the problems connected with the isotopic enrichment of uranium and improvement of enrichment methods and technology.

During the period between the Third and Fourth Geneva Conferences great progress had been made in the production of fuel and its reprocessing after use in reactors. At the same time, much remained to be done — for example, the development of methods for the reprocessing of fast reactor fuels and the improvement of the reprocessing of thorium-containing fuel. "It seems to me," he said, "that unless the problem of fast reactors can be solved it is impossible to resolve the problem of large-scale atomic energy production."

From fission to fusion

Finally, the next step in the development of nuclear power engineering must be the introduction into the fuel cycle of a new type of nuclear fuel: high-temperature deuterium plasma. "As was the case 20 years ago, the basis of the most advanced work on the production of high-temperature plasma of sufficiently high density and temperature is the idea of its magnetic thermal insulation. I should like to emphasize here that thanks to the initiative of an outstanding Soviet scientist, the late Academician Kurchatov, in 1955, work on controlled thermonuclear fusion was declassified; this has had an extremely beneficial effect on the overall development of this important field.

"At present, the overall programme of thermonuclear research provides for experiments in three main directions — experiments to obtain a hot plasma in closed magnetic systems (Tokamak and stellarator) and in adiabatic magnetic traps and experiments in pulsed magnetic fields. Detailed studies on the properties of high-temperature plasmas and the exceptional inventive spirit of the physicists engaged in this problem have made it possible to find optimum conditions for the thermal insulation of plasma and thereby to increase its main physical parameters. Since the Third Geneva Conference it has been possible to increase the plasma parameters by almost an order of magnitude in magnetic mirror units as well. Definite progress has been made in the most advanced methods of fast plasma heating in pulsed magnetic fields.

"Apart from the above-mentioned sections of the thermonuclear programme, which have become conventional, in recent years developments have started in relatively new directions. These include experiments with units which make it possible to generate a highly-dense bunch of high-temperature plasma — 'plasma focus' — in a very small volume. It is true that the further prospects of this method are still not clear, since the experimental conditions are not yet such as would enable us to understand the mechanics of neutron radiation of the plasma focus and its dependence on various physical parameters.

"Very recently, studies connected with the possibility of heating matter with an intense laser beam have begun to develop considerably. The special attraction of this method is that the idea of magnetic thermal insulation of plasma can, in principle, be done away with. In experiments based on this method, the neutron radiation intensity is at present 10^4 neutrons per pulse. However, the unusually rapid progress in increasing the reserve of energy in the laser beam, and the efficiency of the laser itself, on which the prospects of developments in this direction mainly depend, can even in the very near future make the method of laser heating one of the most promising in the whole thermonuclear

programme. Initial steps have also been taken toward the development of what are highly attractive methods from the standpoint of physics — the methods of very fast heating of matter with a high-intensity electron beam.

"Analysis of the present status of the thermonuclear fusion problem shows that, in spite of the appearance of basically new trends, it has not yet gone beyond the stage of developing the physical principles of obtaining such plasma parameters as would make it possible to use the reactions occurring in the plasma for the technical solution of the problems of constructing a thermonuclear reactor. Let us hope that the resolution of the remaining tasks will proceed just as rapidly as before."

Safeguards, Waste, Industry

Academician Bogolubov noted that the further development of nuclear power in years to come would be accompanied by an accumulation of ever-growing quantities of nuclear materials. In this connection, the Conference had placed great emphasis on problems of safeguards and the control of nuclear materials, as provided for by the Treaty on the Non-Proliferation of Nuclear Weapons. The success achieved by the IAEA in drafting a model agreement on safeguards, and the progress made in working out technical ways and means of safeguarding nuclear materials, inspired the conviction that the aims of safeguards as laid down in the NPT would be fulfilled satisfactorily at moderate cost and without detriment to the peaceful uses of atomic energy.

The Conference had studied carefully the improvement of methods of processing and burying waste. Reliable disposal was ensured by methods now being developed or already in use, including the pumping of waste into the ground, the solidification of waste and the burying of waste in salt formations. "It seems to me, however, wrong to release radioactive waste into the seas and oceans," he said, "in view of the possible pollution of the hydrosphere."

Something must also be said about the great change which had taken place since the Third Geneva Conference in the development of research on applied radiation chemistry and the application of radiation-chemical processes in industry.

"In some countries the industrial manufacture of various materials and products with special properties has been undertaken, and processes of radiation synthesis have been applied, on the basis of methods using the modification of polymers by radiation," he said. "It should be pointed out that in the developing countries a great research effort is under way in the field of applied radiation chemistry with a view to the industrial application of radiation processes."

Further, reliable operation of nuclear power stations, and the safety of man, could not be assured without progress in the field of nuclear instruments used for radiometry, dosimetry and the technological control of various nuclear reactions had already been developed and were being

A general view of the exhibition hall. In the background,
a sodium pump developed in France for use in a liquid-metal cooled reactor. Photo: UN


FRANCE
JAPAN


DIMENSIONS REELLES
ACTUAL SIZE

released by industry. This was very encouraging, and gave an assurance that in the very near future complex automated systems would be created on the basis of the most recent advances in microelectronics, by means of which atomic power plants could be reliably controlled and operated.

Radiation and medicine

"The period since the Third Geneva Conference has been marked by considerable progress in the field of the use of radioactive isotopes and of radiation in various branches of medicine," Academician Bogolubov went on. "Methods of radioisotope investigation for the purpose of diagnosing various human diseases have been widely developed in general therapeutic practice, surgery and oncology. The main trends in modern radiotherapy which have been reflected in the papers presented at the Fourth Geneva Conference are these:

— a widening of the range of nuclear radiation applied in radiotherapeutic practice (gamma rays, radiation of betatrons and linear accelerators, proton and neutron therapy);

— improvement of the radiation-physical parameters and of the clinical and methodological foundations of radiotherapy, optimization of programmes for radiotherapy with a view to its individual planning, based on the application of computer technology.

"Of considerable importance for the further improvement of radioisotope diagnostics and radiotherapy is also the establishment of large radiological centres and the training of specialist staff.

"The material before the Conference shows the emphasis placed on the study of the biological effects of the various types of radiation, the investigation of the mechanisms causing harmful radiation effects and remedial measures at the cellular and molecular levels, and possibilities of using means of protection.

"Radiobiology is making its contribution to the solution of an important problem: the supply of a sufficient quantity of wholesome food products for the world's population. This is being achieved by the use of high-yield types of grain crops obtained by the method of radiation selection and by improvements obtained through radiation sterilization. Radiation is being used increasingly to induce useful mutations in microorganisms."

Nuclear Energy and the Environment

Academician Bogolubov noted that the papers presented at the Conference had given particular attention to the problem of the environment: large-scale research was in progress on the manner in which radioactivity reached the external environment and on the penetration of the biosphere by radioactive products and their interactions with it. In every one of the papers presented dealing with this topic it was pointed out that the

Part of the Canadian exhibit.
Featured, a cut-away model of "Slowpoke", an adaptation of the
name of the device in English — Safe Low Power Critical Experiment. Photo: UN

question of the effect of radioactive substances upon man and the biosphere as a whole was one of the knottiest problems of the peaceful use of nuclear energy. The papers showed clearly that the safety of operation of atomic power stations and the pollution of the environment were receiving a vast deal of attention worldwide.

"The comparative assessment made at the Conference of the consequences of the operation of conventional plants and of atomic stations is interesting," he said. "Conventional plants require several thousand times more air for diluting toxic substances to a permissible level than atomic power stations. Furthermore, the use of atomic energy does not involve the consumption of energy and does not result in a steady build-up of carbon dioxide in the air.

"A great deal of attention has been given in the papers to the question of public reaction to the development of the atomic energy industry. This matter undoubtedly requires the closest attention and painstaking work.

"In the course of the Conference an interesting debate took place on ecological problems, on the subject of which the representatives of ten countries exchanged views and replied to the dozens of questions that were asked. Stress was laid in the debate on the rôle of the scientist doing objective research in moulding a public opinion favourable to atomic energy.

"A great deal of light was thrown in the Conference papers on the problems of the importance of nuclear technology for the developing countries; virtually all aspects of the use of atomic energy were covered, and an analysis was made of ways of increasing the contribution of nuclear technology to economic progress."

Nuclear energy was one of the ways of satisfying the rapidly increasing demand for energy in all countries ; it had always had to compete, however, with more traditional ways of producing electric power. It was probably desirable to develop the fuel base for the developing countries' atomic energy industry on a regional basis, with maximum utilization of the countries' own uranium resources, prospecting for which ought to be intensified; while for the enrichment of the developing countries' uranium use could be made of other countries' experience.

The nuclear centres that had been set up in the developing countries were helping to train experts. They were also making possible the development of research in the fields which were of the greatest practical importance for the economy. The charged-particle accelerators and research reactors that had been built in those centres constituted dependable radiation sources for research and a basis for the training of personnel: personnel was obviously one of the most important factors in the use of atomic energy in those countries. Nuclear energy had only recently begun to make its contribution to the economic progress of a number of countries, and there was every prospect that nuclear technology and its many economic applications would promote the economic and the scientific and technological development of a large number of countries with increasing effectiveness.

Co-operating in training

A special place in the papers at the Conference had been devoted to international co-operation in the field of personnel training. Many devel-

oped countries were giving technical assistance for the training of personnel from developing countries. An important rôle in getting this co-operation, particularly multilateral co-operation, under way was being played by the IAEA, which sought to ensure that the training of experts was carried out with due regard for the specific needs and potentialities of the developing countries.

"In this sense the Fourth International Conference on the Peaceful Uses of Atomic Energy has made a great contribution to international co-operation," said Academician Bogoliubov. "A two-week live exchange of experience on the scientific, technical and economic aspects, on the legal and political aspects, and an exchange of information and the training of specialized personnel, will serve a useful purpose.

"In their messages to the Conference, the heads of a number of participating States drew attention to the need for expanding international co-operation in the peaceful use of atomic energy, and to the positive contribution of such co-operation toward relieving international tension and strengthening peace throughout the world; and they emphasized the need for continuing efforts to curb the armaments race in nuclear weapons.

"In this connection, attention was once again drawn to the importance of the Treaty on the Non-Proliferation of Nuclear Weapons... The fact that the Treaty was signed by 98 States and that it has been ratified by three nuclear-weapon States and by 66 States not possessing nuclear weapons bears witness to the broad international recognition of the Treaty's importance. The success achieved by the IAEA in drafting a model safeguards agreement inspires the conviction that the aims of safeguards as laid down in the Treaty will be satisfactorily fulfilled."

The uses of nuclear science

"This Conference has been devoted to purely practical problems of vital importance," said Academician Bogolubov. "It was planned so as to be directly useful not only to scientists and engineers but also to industrial organizers, managers and economists.

"Here, however, I must emphasize the fundamental importance of the part played by pure science. And since I have been given an opportunity to review the work of the Fourth Conference, I should like to stress the part played by pure science research which does not at any given time seem to be of use even to scientists specializing in allied branches. Only afterwards does it appear that what seemed to be quite theoretical pure research often has the incidental effect of leading to the creation of new branches of technology. We may recall in this connection that in the thirties research of the atomic nucleus was considered by many people to be so abstract, so divorced from life, that doubts were expressed as to the expediency of financing it, even on a modest basis.

"Again, long before even the idea of a controlled thermonuclear reaction made its appearance, a purely abstract, theoretical approach to the study of plasma was successfully developed, an approach based, so to say, on the intrinsic interest of the subject. And now it seems that this research subsequently led to a broad field of application in connection with the problem of controlled thermonuclear fusion.

"I shall not give a large number of such examples here. Let me just say that we obviously now have a similar situation in high-energy physics

— i.e., in the physics of elementary particles. There is no sign yet of this leading to broad applications, but it is my profound conviction that the penetration which is thus gradually taking place into the secrets of the inner structure of matter, into the laws governing the interaction of its basic microconstituents, the elementary particles, must undoubtedly lead to big, perhaps quite unexpected, practical applications.

"Everyone is interested, of course, in the fruits of science; but at the same time attention should be given also to the deep-lying roots of the tree upon which such fruits may grow.

"What can be said in conclusion about the prospects which the successes already achieved in the sphere of atomic science and technology are opening before us?

"As may be seen from the papers presented at this Conference, the prospects here are quite extensive; they include applications to medicine, biology in general, and agriculture.

"The work done by the Conference justifies the conclusion that the development of atomic power maintains sufficient purity of the environment; and what is more, the replacement of energy obtained from conventional fuel by atomic energy will lead to a considerable decrease in the pollution of the external environment by toxic substances and to an improvement of the living environment.

"Among the power-consuming applications the desalination of water should be especially emphasized. It must not be forgotten that the problem of obtaining fresh water may be particularly acute in the not-too-distant future. And on account of the great energy consumption required to solve this problem atomic technology is destined to play a decisive part.

"Then there is the problem of designing and improving nuclear engines. Ships with nuclear engines already exist. And when the time comes for flights to distant planets, there is no doubt that nuclear engines will be designed for this purpose, thus contributing to man's conquest of space."

In a closing address Mr. Guy Gresford, UN Director for Science and Technology, noted that in recent years the international community had become increasingly worried about problems of the human environment; this concern was to find a focus at the conference being convened by the United Nations in June 1972 in Stockholm. "In a sense," he said, "the present Conference on atomic energy may be regarded as one of the preliminaries to the Stockholm meeting, since it has emphasized the contribution which nuclear power can make to providing man with clean energy, with a minimum disturbance to the environment."