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RAND RESEARCH MEMORANDUM

THE SOVIET UNION AND THE ATOM: PEACEFUL SHARING, 1954-1958

Anne M. Jonas

RM-2290 November 20, 1958

in brief

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The program for sharing Russian knowledge about peaceful atomic applications is discussed in this Research Memorandum which shows that chief among the factors that motivated the Soviet leaders to initiate such a program were:

- --the greater flexibility of Soviet foreign policy after Stalin's death,
- --the beginnings of an era of Soviet atomic plenty, and
- --certain pressures that were building up from several sources in favor of peaceful atomic sharing.

But there has been a very slow implementation of the initial sharing offers, and active measures have been taken by the USSR bloc to keep peaceful atomic activity outside the Soviet Union at a level that can be controlled by Moscow.

The more advanced Soviet satellite nations are determined to acquire atomic power stations, and several have secured promises of Soviet help in building them. Also, some of the bloc nations are trying in various ways to reduce their atomic dependence on Moscow, and, as their programs continue to grow, more drastic Soviet control measures will probably be required.

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U. S. AIR FORCE
PROJECT RAND

RESEARCH MEMORANDUM

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Anne M. Jonas

November 20, 1958

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Assigned to ______________________

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SUMMARY

During 1954 and 1955, the Soviet Union slowly embarked on a program for sharing Russian knowledge about peaceful atomic applications. Chief among the factors that motivated the Soviet leaders to initiate such a program were the greater flexibility of Soviet foreign policy after Stalin's death, the beginnings of an era of Soviet atomic plenty, and certain pressures that were building up from several sources in favor of peaceful atomic sharing.

An announcement, early in 1955, that the U.S.S.R. would undertake a program of limited nuclear sharing with certain nations in the Soviet bloc was followed by loud propaganda and vague hints that similar offers might be made to non-bloc nations. Only a few, selected nations, however, actually received assistance. Furthermore, even those bloc nations that had contributed raw materials and personnel to the Soviet atomic program since World War II were required to pay for the research reactors and cyclotrons offered them.

Nevertheless, at the first promise of even a limited share in Soviet atomic knowledge, most bloc nations were quick to make grandiose plans for peaceful atomic programs of their own. However, the Soviet Union proceeded from an apparent awareness

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that, sooner or later, a "fourth country" problem could develop within its orbit unless these programs remained limited. Thus far, the very slow implementation of the initial sharing offers, as well as certain active measures taken by the U.S.S.R., have indeed served to keep peaceful atomic activity outside the Soviet Union to a level that can be controlled by Moscow. But the more advanced orbit nations are determined to acquire atomic power stations, and several have secured promises of Soviet help in building them. Also, some of the bloc nations are trying in various ways to reduce their atomic dependence on Moscow, and, as their programs continue to grow, more drastic Soviet control measures will probably be required.

Up to the present, most of the satellite countries, in their effort toward greater atomic independence, have concentrated on building up facilities for training scientists at home rather than in the Soviet Union. Little by little, the research reactors and cyclotrons promised by the Soviet Union in 1955 have been delivered and assembled, and most of them are now in operation. Applications of isotopes in industry, medicine, and research have increased. It is true that most projects are behind schedule. But, given the fact that none of the orbit nations had an atomic program before 1955, the achievement to date is impressive.

Progress has varied from country to country according to the degree of economic and political stability, the level of industrialization, and other factors. At the moment, it appears that East Germany has the most advanced program, with Czechoslovakia second, and Poland coming up fast. China has assigned high priority to a program under which, by 1967, she hopes to have caught up with the rest of the world in the peaceful uses of atomic energy. Also, there are indications that China may be becoming more nearly a political partner than a satellite of Moscow, and according to unconfirmed reports, she has been promised both power reactors and atomic weapons. But the question of just how much military or peaceful assistance the U.S.S.R. is actually prepared to give China must remain unanswered until more information becomes available. Even if future atomic installations in China were to remain under strict Soviet control, it would be to the political advantage of both China and the U.S.S.R. if, to the outside world, they appeared to be in Chinese hands.

Outside the bloc, India, Yugoslavia, and Egypt have been the principal nations to be offered peaceful atomic assistance. India apparently refused to accept the terms stipulated by the U.S.S.R., and the negotiations ended in deadlock. Yugoslavia purchased a research reactor from the Soviet Union, but

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dissatisfaction with the terms of payment and renewed ideological controversy have made future atomic co-operation unlikely. Egypt, a principal beneficiary of the general Soviet program of economic assistance, has received a substantial share of peaceful atomic aid from Moscow.

The U.S.S.R. also has made minor contributions through the International Atomic Energy Agency (IAEA). Primarily, however, it has used its membership in the agency to political and psychological advantage.

Apparently, the Soviet Union embarked on the policy of peaceful atomic sharing with nations inside its orbit as a necessity that could no longer be avoided. Although effective control has been maintained so far, the inevitable expansion of domestic programs will bring new problems to Moscow's relations with its satellites.

Sharing outside the orbit, on the other hand, seems to be chiefly a useful supplementary device by which to attain certain established international objectives. Future offers of assistance to non-bloc nations, therefore, will probably continue to be confined to countries already subject to the over-all "trade and aid" tactics of the Soviet Union.

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THE SOVIET UNION AND THE ATOM:
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I. The Beginnings: 1954-1955

Among the many changes in the Soviet Union that were ushered in by the death of Stalin in 1953 was a new, more flexible foreign policy. In 1954/55, there was evidence not only of a changed approach in relations with satellite nations, but of a growing emphasis on broadening economic and cultural contacts with countries outside the Soviet bloc. In keeping with these developments, a program of peaceful atomic sharing, if carefully planned and controlled, must have appeared as a plausible adjunct to other tactics then being employed in the Soviet Union's relations with nations both within and outside its orbit. With great care and relatively little expenditure, the Soviet leaders could hope to reap large political returns from such a program. For one thing, it could be fitted neatly into the more general "trade and aid" campaign that had begun to be directed at non-bloc nations. Moreover, Russia's willingness to share her atomic knowledge for peaceful purposes

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would lend strength to the theme that she was concentrating on the peaceful possibilities of the atom while the West was preoccupied with building bigger and better bombs -- a theme that had run through Soviet foreign and domestic propaganda ever since Hiroshima.

The policy of emphasizing consumer goods at the expense of heavy industry, which had been inaugurated in the U.S.S.R. under Malenkov's leadership, was followed by similar shifts in priorities in the East European nations. A limited program of peaceful atomic sharing within the Soviet orbit -- particularly any plan for making available isotopes for use in medicine, industry, and agriculture -- was likely to accord well with Malenkov's policy of greater concern with the welfare of the population in the entire orbit. Even after Malenkov was forced to resign in February 1955, and priority for heavy industry was restored in the satellites as well as in the Soviet Union, a peaceful sharing program was still a potentially useful tactic. It could support efforts to improve economic conditions in the satellites, and would help to counteract the political effects of instability in Poland, Hungary, and elsewhere by making the satellite nations appear to the outside world as equal members of a solidified and strengthened bloc.

The fact that the Soviet Union was entering a period of atomic plenty was another incentive to publicize its achievements in the peaceful uses of atomic energy. After World War II, high priority had been assigned to building up a military atomic program in the Soviet Union, despite propaganda to the contrary. By 1954, the Soviet military atomic capability was very nearly equal to that of the United States. Consequently, some raw materials and scientific personnel already had been diverted to advanced work on peaceful applications of the atom.[1] The beginnings of a limited sharing program were foreshadowed, early in 1954, by a flood of articles in the Soviet press on the use of radioisotopes in Soviet industry, medicine, and research. A spectacular announcement came from the U.S.S.R. Council of Ministers on July 1, 1954, to the effect that, a few days earlier, the "first industrial power station using atomic energy" had been put into operation and was producing electric current "for industry and agriculture in the neighboring region."[2] At that time, the West had no reactors in operation that were specifically designed to produce electricity, and the Soviet claim of being "first with atomic power" could not be effectively challenged since all details on the power station were withheld. However, for the rest of the year a flood of propaganda acclaimed the Soviet Union as the world's leader in developing peaceful uses of atomic energy.

In addition, pressures for a peaceful atomic sharing program were beginning to build up which the Soviet leaders could not afford to ignore. Their sources were threefold: they came from the West, from the satellite nations, and from scientists within the U.S.S.R. Most important was the fact that the United States had begun to share some of its peaceful atomic knowledge. In the middle of 1954, the United States amended its Atomic Energy Act. While still protecting U.S. military security, the revised atomic laws provided for considerably greater freedom to share knowledge of peaceful atomic applications. They reflected not only the expansion of peaceful uses of atomic energy in the United States, but also America's desire to promote international co-operation in the field.

There were also, of course, political motivations for a U.S. program of peaceful atomic sharing. Many nations allied to the United States had resented the stringent restrictions of the earlier U.S. atomic laws that had made an effective sharing program virtually impossible. The United States had been criticized for relying on the deterrent effect of its atomic weapons, and there was opposition to the establishment of U.S. bases in some of the allied nations. Atomic disarmament negotiations were deadlocked. President Eisenhower's

proposal to establish an International Atomic Energy Agency under the aegis of the United Nations, made in a speech to the General Assembly in December 1953, was partly an attempt to demonstrate to the world the sincerity of U.S. intentions to promote peaceful uses of atomic energy on an international scale. Eisenhower's proposal stipulated that the "governments principally involved" make joint contributions from their stockpiles of uranium and fissionable materials to the new agency once it was established.[3] The details were to be worked out in private negotiations among the governments concerned.

The Soviet Union agreed to discuss the proposal with the United States, but soon began to exhibit the delaying tactics and unwillingness to compromise so typical of Soviet diplomacy since World War II. After it became apparent that Soviet intransigence would delay the formation of the proposed U.N.-sponsored organization, the United States went ahead with plans for unilateral action.

Under the revised U.S. Atomic Energy Act, bilateral agreements between the United States and other nations were to be a prerequisite for co-operation in the peaceful uses of atomic energy. A partner nation to such an agreement would receive the technical information necessary for construction and operation of research reactors, and would be permitted to lease from

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the United States the nuclear fuel to operate these reactors.[4] In order to finance the research project, it could apply for a U.S. government grant of up to $350,000, or approximately half the cost.[5]

By June 1955, the first such bilateral agreement, between the United States and Turkey, had gone into effect. By mid-July 1955, the United States had signed bilateral agreements with fifteen other nations. Since then, the U.S. program for peaceful atomic sharing has continued to grow in scope and volume.[6] By the end of 1957, research agreements with thirty-five nations, and combined research-power agreements with fourteen more, were in effect. Ten other bilateral agreements had been signed and were ready to become effective as soon as the brief waiting period required by law had elapsed. British activity in this field also has been impressive.[7]

The Soviet Union was forced to "keep face" with the West, and to offer proof of the advanced stage of Soviet atomic science to the West and to nations that had no significant atomic programs of their own. It could not afford to sit back while the West was beginning to help such nations in their peaceful atomic activities.

Further pressures came from the countries of the Soviet bloc. Throughout the postwar period, some of them had

contributed extensively to the Soviet atomic energy program. Most of these "contributions" were exacted by force after Red Army occupation. Uranium ore was mined under Soviet control and shipped to the U.S.S.R. as a part of the reparations payments demanded of the East European nations.[8] The details of China's contribution to the Soviet atomic program are not known, but the U.S.S.R. has admitted that China supplied raw materials.[9] In addition, key scientists from the satellite nations were taken to the U.S.S.R. after the war to work in the Soviet atomic program. Various precision instruments necessary to the program were manufactured in satellite nations and sent to the Soviet Union. Thus, the raw materials, instruments, and personnel available to the East European satellites that might have been used to develop limited peaceful atomic programs at home were being channeled to the Soviet Union. The combined effect of wartime damage to laboratories and postwar Soviet demands was to curtail physics research in the satellite nations severely: research in theoretical physics was extremely limited, while work in applied physics was almost nonexistent.

In the course of 1954, as more and more peaceful applications of atomic energy were being developed in the Soviet Union, work in this field was widely publicized. Articles in the

Soviet press emphasized the use of isotopes in industry, agriculture, and medicine in the U.S.S.R. At about the same time, the orbit regimes were engaged in reshuffling lines of responsibility within their hierarchies to conform to the new Soviet pattern of "collective leadership," and were busy with other matters consequent to the changes in U.S.S.R. leadership and policy. Malenkov's exhortations that more attention must be paid to improving consumer goods industries and the general living standard were being echoed in statements by political leaders in the satellite nations. Scientists, especially in the technically more advanced of those nations, had long wanted a more equitable share in the fruits of the Soviet atomic program to which their nations were contributing. So far, all that had been permitted them for use at home were a few isotopes, purchased from the U.S.S.R.[10] They now saw an opportunity to exploit the general situation by asking for more equipment and materials necessary to peaceful atomic research. Czech scientists had even begun to construct a reactor on their own initiative.[11] Their political leaders, in turn, could argue in Moscow that a limited peaceful atomic program would relieve some pressures from the scientists, help the ailing economies, and serve to heighten the government's prestige at home, thereby enabling them to deal more effectively with the broader problems.

Scientists in the Soviet Union also brought pressures to bear on political leaders to initiate a peaceful atomic sharing program. Long cut off from their colleagues in the West, they were eager to renew international scientific ties and were quick to capitalize on the general post-Stalin "thaw" which permitted some contact with the West. But international professional contacts could thrive only if the Soviet scientists had some freedom to discuss at least part of their work with colleagues in other nations. Physicists in particular, inhibited by the strict secrecy which had surrounded all Soviet atomic activity since 1943, wanted official sanction to publish and to discuss their work on peaceful applications of atomic energy.

A combination of the factors described above -- changes in Soviet foreign policy, a growing Soviet military atomic capability, the beginnings of Western programs for peaceful atomic sharing, and a variety of internal and external pressures -- ultimately led the Soviet Union to initiate a peaceful atomic sharing program of its own.

<u>Russia's First Atomic Power Station -- A Soviet Symbol</u>

In mid-January 1955, the Soviet government announced that it would present to the world a technical report on the first

Soviet industrial atomic power station.[12] The report would be offered to the forthcoming U.N.-sponsored International Conference on Peaceful Uses of Atomic Energy, proposed by U.S. Secretary of State Dulles and scheduled for August.

Soon afterward began a concerted effort to build up the atomic power station as a tangible symbol of Soviet accomplishments in the peaceful uses of atomic energy. The power station became a show piece for visiting foreign dignitaries and technical specialists, and a movie about it was widely shown outside the Soviet Union. Models of the station appeared prominently in Soviet exhibits at various international industrial and trade fairs and at major exhibits within the Soviet Union. As promised, the U.S.S.R. presented a scientific report on the construction and operation of the power station to the first Geneva Conference on Peaceful Uses of Atomic Energy, and this was followed soon afterward by technical reports published elsewhere.[13] The reports revealed that the Soviet atomic power station was a small pilot plant with an electrical capacity of only 5,000 kw.[14] But it had been built from an original design, technical problems connected with power reactor construction had been successfully overcome, and it was effectively producing electricity. The Soviet reports gave no details about comparative costs of nuclear and

conventionally produced electricity. Western specialists estimated that the electricity produced in the pilot station probably cost considerably more per kwh than that produced in conventional plants. Nevertheless, it appeared that the Soviet atomic power plant would serve as a prototype for larger models which, in a few years, could be expected to produce electricity from atomic energy that would be economically feasible.

At the time, British and U.S. accomplishments in the direction of economically feasible atomic power were not so widely publicized as the Soviet developments.[15] Many nations were plagued, as they are today, by serious shortages of conventional sources of power. They were inclined to take literally the vague initial promises of Soviet propaganda, and some, both within the Soviet orbit and outside it, began to hope that the Soviet Union would soon offer to help them develop atomic power stations of their own. The reluctance of the U.S.S.R. to follow up its vague propaganda promises with any kind of tangible assistance, particularly to nations not in the Soviet bloc, did not become apparent until later.

Toward Intra-Orbit Sharing

On January 18, 1955, three days after the announcement that the Geneva Atomic Energy Conference would hear technical

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reports on the atomic power station, the U.S.S.R. Council of Ministers stated that limited peaceful nuclear sharing would be undertaken with some of the nations in the Soviet bloc.[16] The announcement indicated that, in return for their contributions of raw materials to the Soviet atomic program, the U.S.S.R. had offered to help China, Poland, Czechoslovakia, Rumania, and East Germany develop programs of research in the peaceful applications of atomic energy. In April, the offer was extended to include Hungary and Bulgaria.

In the spring of 1955, scientific delegations from the various recipient nations went to Moscow to negotiate the implementation of the Soviet offer. The foreign scientists held lengthy discussions with outstanding Soviet physicists and engineers, and were given an opportunity to see what research was being done on peaceful atomic applications at some Soviet scientific institutions in Moscow, Leningrad, Kiev, and Kharkov. They were shown some of the experimental atomic reactors and primary particle accelerators in operation in the Soviet Union. They visited the Soviet atomic power station, and its operation was explained to them.[17] The negotiations culminated in individual agreements between their countries and the Soviet Union. Under the terms of the agreements, the Soviet Union undertook to do several things during 1955 and 1956 to promote peaceful atomic programs in the recipient nations. Specifically, the Soviet Union would:

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1. Supply Soviet-made, isotope-producing experimental atomic reactors and primary particle accelerators.

2. Send Soviet specialists to the recipient nations to assist in assembling these machines and putting them into operation.

3. Deliver unspecified amounts of radioisotopes until the supplied reactors began to produce isotopes.

4. Furnish free of charge necessary scientific and technical documents relating to these reactors and accelerators.

5. Train specialists from the recipient nations at Soviet scientific research institutes and universities. These specialists would receive instruction in atomic reactor techniques and in the application of isotopes to science and engineering.[18]

By the end of May 1955, the Soviet Union had signed such agreements with all the principal nations of its orbit. On superficial examination, the announcements about the Soviet Union's initial sharing venture created a favorable impression. The accompanying propaganda stressed its significance beyond all reasonable limits. A more careful analysis, however, would reveal that, given the level of nuclear technology in 1955, what the Soviet Union offered its satellites was very little indeed.

First, the equipment offered, while essential to basic training in nuclear technology, was not as impressive as Soviet

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propaganda claimed. According to official statements, each recipient nation was free to choose the type of reactor it wanted, but it appears that not all types were shown the scientists during their orientation trips to the Soviet Union. For example, only the Chinese delegates were permitted to see a heavy water reactor; scientists from the other satellite nations saw only the atomic power station and the experimental reactor at Moscow State University, fueled with enriched uranium and using ordinary water as a moderator and coolant.[19] The Moscow State University reactor is a small one, with a heat capacity of 300 kw.[20] It has served as a prototype for a larger research reactor, with a heat capacity of 2,000 kilowatts,[21] which has recently begun operation.

The experimental reactors "chosen" by all the European satellites were similar in design to the Soviet 2,000-kilowatt reactor. A reactor of this type is effective for training purposes and isotope production. A Soviet specialist has described the research applications of this type of reactor as follows:

> A feature of the design is the provision of a large number of channels for the irradiation of samples of different types, including biological objects, and for the production of radioactive isotopes. The reactor can also be used for the engineering and physical testing of materials and for studying their behaviour under irradiation of varying intensity.

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> In the construction of atomic reactors, a feature particularly stressed is a design permitting the simultaneous execution of the greatest possible number of experiments. For example, each reactor will be provided with 10 neutron beam ports.
>
> The excess reactivity of the reactors is such that they can be used for the production of a large number of different types of radioactive isotopes. Using only half their excess reactivity, the nuclear reactors being designed for Poland, Czechoslovakia, Hungary, Rumania, Bulgaria, and the German Democratic Republic will each be able to produce such isotopes as radioactive cobalt up to 1,500 curies per month, and radioactive sodium up to 5,000 curies per hour.
>
> Thus, the atomic reactors being designed by the Soviet Union for the above countries will enable them to produce many radioactive isotopes in quantities amply sufficient to meet all their requirements.[22]

China was privileged to choose a research reactor with a heat capacity of 6,500 kw which, if necessary, can be increased to 10,000 kw. The Chinese reactor is fueled by uranium rods containing U^{235} to a 2 per cent enrichment, and uses heavy water as a moderator and coolant.[23] With some modifications, this reactor is similar in design to the U.S. CP-3 reactor, which went into operation at the Argonne National Laboratory in 1944. A Soviet heavy water reactor that began operating in 1949 seems to have been the prototype for the Chinese reactor.[24]

Given the present state of nuclear technology, then, the research reactors initially offered the satellite nations were training instruments as basic to atomic physics as is a blackboard to a classroom. The particle accelerators were equally elementary. They were cyclotrons capable of accelerating alpha-particles to 25 Mev.[25] (The prewar U.S. cyclotron at Berkeley, California, accelerated alpha-particles to 35 Mev.) While useful in teaching and training, such accelerators are inadequate equipment for advanced research on subnuclear particles through the use of high energy.

Despite the fanfare about its atomic power station, the Soviet Union did not at first offer power-producing reactors to the satellite nations.

The official announcements made no mention of how the costs of the initial Soviet sharing arrangements were to be met. However, it is clear that, despite their free contributions of raw materials and equipment to the Soviet atomic program, the recipient nations were expected to pay for what they received in return. Discussing the Soviet-satellite agreements in a report to the first Geneva Atomic Energy Conference, Lavrishchev, while speaking circuitously, made it clear that only technical documents would be supplied free of charge:

> The Soviet Union does not look on the assistance it is offering in the peaceful uses of atomic energy as a commercial undertaking. Although the Soviet Union has spent enormous sums on the development of atomic reactors and accelerators, the necessary scientific and technical information and the experience it has gained are being made available to other countries free of charge. <u>These countries will pay only the actual cost of manufacture of the equipment to be supplied to them under the agreements concluded</u>.[26] [Author's italics.]

Having contributed without remuneration to the Soviet atomic program throughout the postwar period, the satellite nations did not accept without argument the payment stipulations set forth by the Soviet Union. For example, the Minister for Atomic Energy Utilization in Poland indicated, as late as December 1956, that negotiations were still going on with the U.S.S.R. concerning the prices to be paid by Poland for her research reactor and cyclotron; the Soviets, he said, "had agreed to revise the previously fixed block prices, with a view to lowering them."[27] Ultimately, the research reactor alone cost Poland about a million dollars.[28]

Although the Soviets had promised action on the initial sharing offers for 1955 and 1956, most of the Soviet commitments under the agreements were still in the planning stage as 1955 drew to a close. Isotope shipments to the satellites had been increased, a limited number of scientists and engineers had been accepted for training in the Soviet Union, and some technical documents had been supplied. But actual construction of the promised reactors and cyclotrons had not begun.

Throughout 1956, all the satellite nations continued to encounter delays in Russia's implementation of her sharing offers. Some construction of buildings to house the promised research reactors got underway late in the year, but none of the reactors was ready for operation in 1956 as had been promised. The satellite nations, eager to build up peaceful atomic energy programs of their own, were unhappy about these delays. Furthermore, the Soviet Union was finding out that the nations of its orbit, as their atomic energy programs developed, would demand more than was initially offered them, taking advantage of the Soviet Union's continuing need for their uranium. In addition, the Soviet Union apparently was beginning to realize the desirability of making sure that atomic energy developments in the satellite nations did not grow to a point beyond the Soviet Union's control.

Promises and Overtures to Non-Bloc Nations

As soon as the Soviet Union had announced its decision to share some peaceful atomic knowledge with the satellites,

it began to hint that similar offers might be made to other nations. Such hints lent support to other Soviet tactics which were then enjoying priority in international politics. Intensive efforts were already underway to increase trade with non-bloc countries and to encourage underdeveloped nations in Asia and the Middle East to accept various kinds of Soviet technical assistance. In order to gain support for its "trade and aid" campaign and other objectives, the Soviet Union now began to take advantage of the fact that many nations of the world wanted a peaceful atomic capability of their own. Propaganda referred to possible atomic aid, and Soviet delegates to various U.N. technical committees began to make vague offers to train young physics students from underdeveloped nations at universities in the U.S.S.R. Specific atomic aid offers to individual countries outside the Soviet orbit did not follow immediately.

There were other indications, however, that Soviet policy on international atomic co-operation was changing. By the middle of 1955, the Soviet Union had begun to invite foreign nuclear technicians to see some of its peaceful atomic installations and to attend scientific conferences. A sudden and somewhat spectacular effort was made to gain wide publicity for Soviet atomic energy accomplishments before the 1955

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U.N.-sponsored International Conference on the Peaceful Uses of Atomic Energy convened. In mid-June 1955, without any previous warning, key scientists in forty-one nations received invitations to a conference on peaceful uses of atomic energy to be held in Moscow. The conference was sponsored by the Soviet Academy of Sciences and opened on July 1.[29] Many Western scientists, feeling that the Soviet Union was duplicating and thus defeating the purpose of the U.N.-sponsored conference that was to open the following month, had declined the invitation. However, in addition to scientists from Soviet orbit nations, delegations from India, Japan, Finland, Sweden, Egypt, Israel, and Yugoslavia attended. They heard papers by leading Soviet physicists and saw the Soviet atomic power station and other centers of Soviet research on peaceful uses of atomic energy.[30] They were favorably impressed. Similarly, Soviet papers read at the subsequent Geneva Conference effectively convinced the world of the maturity and quality of Soviet work in the field.

For Soviet physicists, long denied any direct communication with Western scientists, the Moscow conference in July and the U.N.-sponsored conference in August marked a real turning-point in Soviet policy on international atomic co-operation. Since then, Soviet physicists have regularly

attended scientific conferences in the West, and Western specialists have frequently been invited to the Soviet Union. Traditional international scientific interchange has once again become a reality for those Soviet physicists who work on peaceful uses of atomic energy.

Indications of a change in the Soviet attitude toward the proposed International Atomic Energy Agency also became evident about the time of the 1955 conferences. In his opening remarks to the Geneva "summit" meeting of the four great powers, in July 1955, Bulganin stressed Soviet support for "broad international co-operation" in peaceful uses of atomic energy. Soviet intransigence had previously prompted the United States to go ahead with plans to develop the agency irrespective of Soviet participation. Bulganin now indicated, however, that, after the International Atomic Energy Agency was created, the Soviet Union would contribute "an appropriate amount" of fissionable material for its use.[31]

Late in July, TASS reported from New Delhi that several Indian atomic physicists would shortly visit the Soviet Union for a further exchange of views on a previous Soviet offer to aid India in developing atomic research.[32] (Although the final communiqué had not mentioned it, the matter apparently had first come up during talks between Nehru and the Soviet leaders in Moscow a month earlier.) The Indian scientists, headed by Dr. H. J. Bhabha, Chairman of the Indian Atomic Energy Commission, spent two weeks in the Soviet Union in September. They visited Soviet institutions engaged in peaceful atomic research, including the atomic power plant and the Institute of Physical Problems. They exchanged technical views with leading Soviet atomic physicists.[33] But the visit did not result in an agreement for Soviet atomic aid to India, and the matter was still pending when Bulganin and Khrushchev made their tour of Southeast Asia late in 1955. Soon after their arrival in India, Bulganin said in a speech: "For our part we are ready to share our experience with you on the construction of industrial establishments, power stations, hydro-projects, the use of atomic energy for peaceful purposes and other achievements.[34] Officials who accompanied Bulganin and Khrushchev held further talks with Indian officials, in which an atomic aid agreement apparently was again discussed along with other matters.[35] Whatever went on during the discussions, the subject of Soviet atomic aid to India was dropped abruptly, and has not been raised since. The Soviets undoubtedly had refused to agree to India's terms. India, on the other hand, being the possessor of one of the world's best deposits of monazite sands rich in thorium, was in a good bargaining

position. At the time of the Bulganin-Khrushchev visit, an Indian processing plant was already successfully extracting large amounts of thorium from these sands. India was receiving some assistance from the West, and Dr. Bhabha had publicly indicated that, if necessary, she could be self-sufficient and would develop her atomic research program whether further outside aid became available or not.[36] She was therefore in no way obliged to accept Soviet atomic aid on terms she considered unfavorable.

Negotiations concerning a peaceful atomic aid agreement between the Soviet Union and Yugoslavia began in Moscow in August 1955. S. Vukmanovic, Vice Chairman of the Yugoslav Nuclear Energy Commission in addition to other official duties, headed a delegation which had come to Moscow to follow up certain general agreements on resumption of Soviet-Yugoslav relations that had been concluded during the visit of principal Soviet leaders to Belgrade the previous May. In the course of these negotiations, the question of collaboration on peaceful uses of atomic energy also was discussed.[37] The Soviet Union offered Yugoslavia a reactor, a cyclotron, and certain raw materials necessary to an atomic energy program, including uranium and graphite. Vukmanovic indicated that Yugoslavia had accepted "in principle" and agreed to discuss the details later.[38] Another series of Soviet-Yugoslav talks, this time dealing exclusively with atomic co-operation, began in Moscow in late November.[39] These negotiations were still in progress at the turn of the year.

By the end of 1955, then, the Soviet Union had offered specific atomic aid to two nations outside its orbit. The talks with India had resulted in a deadlock. Offers of atomic co-operation with Yugoslavia had led to an agreement to exchange documents, students, and specialists.[40] Negotiations were going on for providing Yugoslavia with basic atomic equipment similar to that offered the satellite nations, but no agreement had been reached. There were indications that the Soviet leaders were looking more favorably on East-West scientific contacts and were now planning to support the U.N.-sponsored International Atomic Energy Agency. The experience with India had shown that not all nations outside the Soviet orbit were willing to accept Soviet atomic aid without questioning the terms under which it was offered.

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II. Steps to Limit Bloc Activity

The Potential Threat

Encouraged by the initial Soviet promises of early 1955, scientists in the satellite nations began at once to plan for the development of peaceful atomic energy programs. To a limited extent, some scientists, notably in East Germany, Czechoslovakia, and Poland, had continued to engage in theoretical nuclear research during the postwar years, but shortages of necessary equipment and information had impaired even theoretical work. Now, plans to expand existing research programs were made in all of the satellite nations, governmental planning commissions for nuclear energy were quickly organized, and projects were begun for setting up nuclear physics institutes.

The first tangible result of the initial Soviet sharing offers was a considerable increase in isotope shipments to the satellites. By the end of 1955, most of the recipient nations had set up training schools to promote more extensive use of isotopes in industry, medicine, and research, and isotope applications had increased considerably. For example, sixty Czech industrial enterprises were using isotopes in industrial testing and had tested over 2,000 products by this method in 1955.[1] Hungary had completed a mobile laboratory designed to use isotopes for testing industrial equipment,[2] and had set up an isotope laboratory for use in agricultural experiments.[3] Increased use of isotopes in Poland had prompted the Ministry of Health to publish special safety regulations for workers handling them.[4]

Physicists from the orbit nations were attending Soviet scientific conferences more frequently. At home, they served on the nuclear planning commissions of their governments and on committees set up in the academies of science. It was up to them to help select the optimum designs for the proposed nuclear research centers and to decide the emphasis of future work.[5] Busy as they were making plans for the future, they soon became impatient about Soviet delays in making available the promised research equipment. Also, officials of satellite governments were objecting to the prices being charged.

On the other hand, in an age when the major world powers were making spectacular advances in nuclear research, a domestic atomic energy program was becoming an increasingly important symbol of national prestige. The more advanced such a program, the better did it serve national interests. After years of depriving most of the nations of its orbit of any

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share in its atomic plenty, the Soviet Union now had given official approval for domestic peaceful atomic programs to be set up. The nations of the Soviet orbit, anxious to develop these programs as quickly and completely as possible, knew that they could not depend for assistance on any source except the Soviet Union. Despite their dissatisfaction with the unfavorable terms and the delays, they were prepared to ask the U.S.S.R. to expand its initial offer.

By the time the Twentieth Party Congress convened, in February 1956, it was public knowledge that the U.S.S.R. planned to construct an extensive network of atomic power stations under its Sixth Five-Year Plan. According to Soviet officials, some of these were to be in operation on a commercial scale by 1960.[6]

Some of the nations of Eastern Europe faced severe power shortages and could argue convincingly that their entire national economy and industrial output would benefit from having atomic power stations installed at the earliest possible date. Others, like Poland, though adequately supplied with coal and other conventional power sources to take care of immediate future needs, nevertheless wanted their own atomic power reactors. Training the specialists required to build and operate a network of atomic power stations was bound to be a slow and complex task. Quite understandably, the satellite leaders were looking ahead to a day when they would have extensive peaceful atomic energy programs of their own. These various interests naturally resulted in new pressures and demands on the U.S.S.R.

Having opened its Pandora's box of peaceful atomic plenty a bit, Moscow now faced a dilemma. Any improvement in the national economy within the communist orbit would be of direct benefit to the Soviet Union. East Germany, Poland, and Czechoslovakia, in particular, could contribute more of the advanced precision tools and components necessary to the Soviet atomic power construction program if they were trained in power reactor construction.

On the other hand, atomic energy activity within the orbit nations had to be strictly controlled and kept under constant surveillance, in order to avoid a "fourth country" problem that would complicate Moscow's relations with orbit nations. Small research reactors are training instruments, but atomic power reactors can also produce weapon-grade plutonium. Even before the danger of a "fourth country" problem became acute, there would be other potential difficulties if strict control were not maintained. For example, as the number of trained atomic physicists increased, there might be attempts

to build, independently, complex installations such as isotope separation plants which would reduce the satellites' dependence on atomic assistance from the U.S.S.R. Also, advances in reactor design -- particularly in breeder reactor design -- could reduce the need for isotope separation plants and prompt orbit scientists to try to construct such reactors independently.

Another fact which the Soviet leaders had to take into account was that any effort to start atomic power programs in the satellite nations would be a drain on the ambitious plans for an atomic power network within the Soviet Union. As they became more sophisticated, the atomic scientists in satellite nations would require increasingly complex research tools from the Soviet Union. If refused, they would eventually learn to construct them independently. Sooner or later there would be the danger of a major theoretical or technical "breakthrough" by satellite scientists, which might serve them as an effective bargaining point to force extensive Soviet concessions.

As long as possible, Moscow denied requests for power reactors from satellite nations, and took steps to insure that all advanced nuclear research would continue to take place in the Soviet Union, where scientists from orbit nations could be more effectively controlled.

The Joint Institute

In March 1956, government officials and leading scientists from ten orbit nations -- Albania, Bulgaria, Hungary, East Germany, China, North Korea, Mongolia, Poland, Rumania, and Czechoslovakia -- were summoned to Moscow to discuss the organization of a co-operative nuclear research institute.

There is little doubt that plans for the Institute had been completed by Soviet officials and scientists in advance. The opening session heard lengthy reports by Soviet spokesmen on how the Institute was to be set up,[7] and the U.S.S.R. representatives continued to lead the discussions throughout the meeting. Members of the Soviet delegation included three senior nuclear physicists specializing in research with high-energy machines, who had been decorated for their scientific achievements:[8] D. I. Blokhintsev, one of the designers of the first Soviet atomic power station;[9] V. I. Veksler, co-inventor of the synchrotron;[10] and M. G. Meshcheriakov, who had been instrumental in setting up the U.S.S.R.'s first major high-energy physics research laboratory soon after World War II. Also representing the U.S.S.R. were Academician A. V. Topchiev, who holds a powerful administrative position as Chief Scientific Secretary of the Presidium of the Academy of Sciences, U.S.S.R.; and a highly-placed official in the Soviet Ministry of Foreign Affairs, S. K. Tsarapkin. Tsarapkin had demonstrated his ability as a negotiator during his years as a Soviet representative on the U.N. Atomic Energy Commission, the Commission on Conventional Armaments, and at important international conferences. He could be relied on to act as "trouble-shooter" if any major objections to the Soviet proposals arose.

The agreement to establish the Joint Institute of Nuclear Research, signed by the participants on March 26, 1956,[11] made only one minor change in the Soviet recommendations: although earlier newspaper accounts of the meeting had spoken of plans to organize an "<u>Eastern</u> Institute of Nuclear Research,"[12] the official name now became the <u>Joint</u> Institute of Nuclear Research. The propaganda advantages of this nuance have been exploited ever since.

The Soviet Union turned over to the new Joint Institute, free of charge, the buildings and entire equipment of two of the nuclear research laboratories of the Academy of Sciences, U.S.S.R., the Institute of Nuclear Problems and the Electro-physical Laboratory,[13] both located on the Volga River about eighty miles from Moscow. Since then, as the Joint Institute has expanded, a new town, Dubna, has sprung up at this site, which provides living accommodations for the Institute's growing personnel.[14]

[redacted]pment of the laboratories turned over to the new Institute by the Soviet Union included a 680-Mev proton synchrocyclotron, built in 1949,[15] and a 10-Bev proton synchrotron then under construction, which has since been put into operation at full capacity.[16] The 680-Mev high-energy accelerator is the largest machine of its kind in operation anywhere in the world. Although some accelerators in the United States and England operate at a higher energy capacity, this machine is important because it produces an intense proton beam in an energy range particularly crucial for certain studies of mesons.[17] (A machine of similar design at the University of Rochester operates at a capacity of 240 Mev.) In addition, the Soviet machine is equipped with elaborate auxiliary equipment for conducting experiments. American physicists who have seen it have been very favorably impressed.[18] In 1957 the machine was completely rebuilt to increase its efficiency.[19] The 10-Bev proton synchrotron is the world's foremost operating high-energy machine, with the 6-Bev machine at the High Energy Lab at Berkeley, California, second in energy capacity.

The organizational structure of the Joint Institute of Nuclear Research was stipulated by the U.S.S.R., and agreed to by the other participants, at the March 1956 conference. The pattern was a familiar one: an elaborate bureaucracy of

[redacted]

officials and subofficials was designed to give the appearance of a democratic structure while concealing guarantees of ironbound Soviet control. The activities and policies of the Joint Institute are controlled by the director, who has broad powers, two deputy directors, a Scientific Council, and a Finance Committee. Each laboratory has its own director, also powerful, and its own Scientific Council, with the lab director as chairman.

The director of the Joint Institute is elected by representatives of the member states to serve for three years. The organizational conference unanimously elected Professor D. I. Blokhintsev of the U.S.S.R. to the post.[20] The director's powers include the right to hire and fire personnel, to increase the salaries of highly qualified personnel up to 50 per cent,[21] and to appoint an administrator to handle the Institute's construction and business affairs.[22] The director plays a leading role in drawing up the annual budget to be approved by the Finance Committee. He serves as chairman of the Scientific Council.[23]

The two deputy directors of the Institute serve under the director and are elected by member states for a two-year term. The scientists elected at the organizational conference and presently serving are Dr. Marian Danysz of Poland, and Dr. Vaclav Votruba of Czechoslovakia.[24]

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All policy concerning the research program of the Institute is ostensibly made by the Scientific Council, on which each member state may have up to three representatives. The Scientific Council meets at least twice a year to review accomplishments, to plan the future research program, and to act on all other questions relating to the scientific activity of the Institute.[25] The U.S.S.R. has control of the Scientific Council, for not only is Director Blokhintsev its chairman, but all laboratory directors are entitled to representation and a vote,[26] and each of the present five laboratories is headed by a Soviet scientist. In practice, then, the Scientific Council has been primarily a "rubber stamp" unit which approves the recommendations of the Institute's directors and other key officials.[27]

All budgetary and financial matters connected with the operation of the Institute are ostensibly managed by decision of a two-thirds majority of the Finance Committee, on which each member state has one representative. The Finance Committee must meet at least once a year,[28] and its chairmanship rotates among the member states.[29] The Institute is maintained, operated, and expanded from funds contributed by member states according to a percentage scale. It pays the salaries of all its workers and scientists, regardless of nationality.[30] The U.S.S.R. is by far the largest single contributor, supplying 47.25 per cent of the Institute's total budget.[31] This percentage excludes the initial Soviet gift of laboratories and equipment, which Soviet sources have valued at more than half a billion rubles[32] (approximately a hundred million dollars at the present exchange rate). Other members contribute to the over-all budget as follows: China -- 20%; East Germany and Poland -- 6.75% each; Czechoslovakia and Rumania -- 5.75% each; Hungary -- 4%; Bulgaria -- 3.6%; Albania, North Korea, and Mongolia -- .05% each.[33] No figures have been issued on the contribution of North Vietnam, which joined the Institute in September 1956. Although the organizational agreement makes provision for the percentage scale to be altered if new members join, apparently North Vietnam has not been assessed. Typically, the ruble total for annual expenditure at the Joint Institute has never been published.

The Scientific Council met for the first time on September 24, 1956, to approve the proposed research plan for the new Institute's first year and to elect directors for the three laboratories formed from the former Soviet institutions now under its jurisdiction. All three men elected were senior Soviet scientists: V. I. Veksler was chosen director of the Laboratory of High Energy Physics; V. P. Dzhelepov, director of the Laboratory of Nuclear Problems; and N. N. Bogolyubov, director of the Laboratory of Theoretical Physics. The Council elected still another Soviet scientist, I. M. Frank, to become director of the Laboratory of Neutron Physics which was to be established shortly.[34] Veksler, Bogolyubov, and Frank have continued to serve in these posts; Dzhelepov was replaced by Bruno Pontecorvo in December 1957.[35] At a later meeting, in November 1957, the Scientific Council approved the establishment of a Nuclear Reactions Laboratory, and elected Georgi Flerov, a senior Soviet scientist who has pioneered in fission research, to be director of the new lab.[36] Thus, the Joint Institute has five laboratories at present, all with Soviet directors.

At its first session, the Scientific Council also approved plans for developing and expanding the Institute's research program during the period 1956-1960. Several new research facilities were to be constructed, including an experimental nuclear reactor with high intensity neutron beams for the Laboratory of Neutron Physics, a cyclotron to accelerate multi-charged ions for the Laboratory of Nuclear Problems, and an electronic computer for the Laboratory of Theoretical Physics. A factory to manufacture special physics apparatus was to be built, and a radio-chemical laboratory was to be established.[37]

The U.S.S.R. is admittedly pushing theoretical research in high-energy physics. From the outset, it was intended that the Joint Institute should concentrate on this field, as the two Soviet institutions that formed its nucleus had done previously. Work in all five laboratories, therefore, centers on various problems of high-energy research, and the plans for expanding the Institute that were approved at the initial meeting of the Scientific Council are being carried out.

The most spectacular achievements to date have been those at Veksler's Laboratory of High Energy. The giant new synchrocyclotron, put into operation in April 1957, is being used for significant research.[38] Officially, this machine belongs to Pontecorvo's Laboratory of Nuclear Problems; but the work of his and Veksler's laboratories is closely connected and to a certain extent interchangeable. A large diffusion chamber and other equipment to study unstable particles have been built at Pontecorvo's laboratory, and a large liquid hydrogen chamber is under construction.[39] Research at Veksler's laboratory concentrates on problems related to the nature and interaction of elementary particles, including anti-particles, and on the development of new research methods and instruments to carry out this work.[40] Experiments conducted in Pontecorvo's Laboratory of Nuclear Problems emphasize nucleon and meson scattering and interaction.[41]

Research at Bogolyubov's Laboratory of Theoretical Physics concentrates on problems related to quantum theory. Frank's Laboratory of Neutron Physics is concentrating on neutron spectrometry and has designed the experimental high-impulse neutron beam reactor.[42] The reactor is designed to have a tunnel six-tenths of a mile long for experiments with the pulsed neutrons it would emit, but there was difficulty with the design, and in mid-1957 it seemed as though the project might be abandoned.[43] (In the United States, scientists use a cyclotron, not a reactor, as a research tool for work of the type planned for this machine.[44]) Flerov's new Nuclear Reactions Laboratory is concentrating on work on transmendelevan elements.[45]

In addition to the fact that research at the Joint Institute is controlled by the Soviet Union, there is only minimal participation by senior scientists from the orbit nations. For the satellite countries, the Joint Institute serves primarily as a training center. Soviet scientists are openly credited with the major achievements involved in constructing the new research machines and with leading the teams that have reported significant findings.[46]

Clearly, therefore, the orbit nations are getting a very poor return for their investments in the Institute. Collectively,

they contribute slightly over 50 per cent of the total operating expenses. When the 1958 budget was adopted, the actual amounts contributed by member states were increased by an unspecified figure.[47] By contrast, the total personnel of the Joint Institute in September 1956 numbered 1,300, of whom 300 were scientists.[48] Only between 20 and 50 out of this group of 1,300 were from member nations other than the Soviet Union.[49] Thus, while orbit nations were contributing more than half the budget of the Institute, they were represented on its staff by less than 4 per cent of the total personnel. The number of scientists from satellite nations increased somewhat during 1957 and 1958, but it is still only a small part of the Institute's staff. For example, there are now approximately 20 Polish physicists, mostly young trainees, and a similar number from Czechoslovakia.[50] A few senior scientists from Poland, including Doctor of Physical Sciences Jan Rzewuski, apparently did advanced research in Bogolyubov's Laboratory of Theoretical Physics during 1957.[51] The most significant accomplishments so far by non-Soviet personnel have been work on anti-particles and the construction of a large bubble chamber by a group of Chinese physicists in Veksler's laboratory. The group is directed by Professor Wang Kang Chang.[52]

Despite the fact that they are forced to contribute funds to the Joint Institute, the orbit nations would prefer to train their young scientists at home. Their indifference concerning the Joint Institute is understandable, inasmuch as their primary concern is to develop atomic power programs, and the high-energy research of the Joint Institute has no direct connection with atomic power. Polish scientists have been particularly frank about their high opinion of Western science, and are anxious to get American physicists to come and help them expand their domestic peaceful atomic program.[53]

The Joint Institute is empowered to co-operate directly with nuclear research centers in the member states,[54] and has also exchanged publications and visits with Western research centers.[55] So far, this aspect of the Institute's work has not reached significant proportions. Recent agreements have channeled direct exchanges between member states through their respective academies of science.[56] Nonresident scientists from member states have attended several working conferences at the Institute; one on experimental techniques in high-energy physics was held in November 1957, and another, on nuclear spectroscopy, in February 1958.[57] Individual Western scientists have visited the Institute while they were in the U.S.S.R. for scientific conferences elsewhere. But most of

them stayed only long enough to examine its major equipment, and did not participate in its research program.

Like the first Soviet atomic power station, the Joint Institute quickly became a political symbol of Soviet concentration on the peaceful atom. It has been widely shown to foreign diplomats accredited to Moscow, to visiting high-level delegations, and to foreign newsmen.[58]

Clearly, the Joint Institute is an important high-energy research center with good equipment and competent scientists. However, it has been, for the satellite nations, more of a burden than an asset. No doubt, this will continue to be the case, and wherever possible these nations will try to develop peaceful atomic programs at home, soliciting what help they can obtain from the West. Forced contributions to the Institute's budget will continue to drain their resources, while the Institute will remain, in essence, a Soviet research institution. New high-energy research centers are now being built in the U.S.S.R.[59] Since this field enjoys the highest priority, the equipment at the Joint Institute will eventually become obsolete. At that point the Institute may disband, with all equipment reverting to the Soviet Union as provided in the organizational statutes.[60] Until then, the Joint Institute will continue to yield both political and scientific benefit to the Soviet Union.

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<u>Other Measures</u>

The Hungarian revolt in the fall of 1956 and the ensuing events in Poland had two effects on peaceful atomic programs in the Soviet orbit. First, they re-emphasized to the Soviet leaders the necessity of maintaining strict control over atomic energy activity in bloc nations. Second, the ensuing disruption of the elaborate system of economic interdependence and credits in the Soviet bloc not only delayed the implementation of the initial sharing offers, but also required considerable reorganization of economic exchanges within the bloc.

The ultimate result of this reorganization was an increased role for the Council for Economic Mutual Assistance (CEMA) in the Soviet Union's economic relations with its East European satellites. CEMA had been set up by the U.S.S.R. in 1949 as a means toward establishing economic control over the new satellite nations and an aid in the latter's postwar industrial development. Bulgaria, Hungary, Poland, Rumania, Czechoslovakia, and the U.S.S.R. were charter members; East Germany and Albania joined later.[61] The significance of CEMA had declined considerably in the years prior to the Hungarian revolt. After the uprising, however, its powers and functions expanded. Early in 1957, a plan was worked out for co-ordinating the development of principal industries in member nations through CEMA. The basic idea was to divide the labor, as it were, among various nations of the Communist orbit, with each concentrating on supplying the commodities it could produce most cheaply and effectively. The parallel industrial complexes on the Soviet model, which were set up in the European satellite nations during the first decade after World War II, had proved a costly and inefficient arrangement. The new plan is designed to strengthen the economy of the Communist bloc as a whole, thereby presumably benefitting also the individual nations. Actually, however, most of the benefits accrue to the Soviet Union. As a Soviet spokesman has said, "Every new factory or mine that goes into operation in the Soviet Union, China, Poland, or Czechoslovakia not only promotes the advance of the economy of that particular country but makes a notable contribution to strengthening the economy and defensive might of the world socialist system."[62] CEMA has taken a variety of measures designed to increase the economic interdependence of member nations, and has established permanent commissions for economic, scientific, and technical co-operation among basic branches of the fuel, metallurgical, and engineering industries of member states.[63] Initially, the plan to co-ordinate industries applied only to the years 1958-1960; later it was extended to cover industrial development for the next ten or fifteen years.[64]

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However costly and inefficient some of their industries may be, the orbit nations are reluctant to give them up, and have opposed the new policy.[65] The measures taken in 1957 did not strengthen CEMA as much as had been hoped, and in 1958 Khrushchev departed from the prepared text of a speech in Budapest to indicate personal dissatisfaction with the status of bloc efforts at economic integration.[66] Shortly afterward, member states were called to Moscow for talks on further measures to raise CEMA's efficiency. The new importance of the organization was demonstrated by the fact that the meeting was attended by high-ranking party leaders from the member nations, and that representatives from Asian Communist countries (China, North Korea, North Vietnam, and Mongolia) were also invited. There is evidence that these Asian countries will participate actively in CEMA's future work, although they have not formally joined the organization. In addition, there are indications that the CEMA machinery may be used, in the future, to work out long-range plans for national development undertaken with Soviet assistance.[67]

The strengthening of CEMA is serving to tighten Soviet control and to increase the economic interdependence of bloc countries. Integration of the chemical, metallurgical, and hydroelectric power industries within the bloc has already

begun.[68] It should be pointed out that industrial support from the fields of chemistry and metallurgy is particularly important to the development of a meaningful peaceful atomic energy program, especially an atomic power program. The new measures will thus create further obstacles to efforts by the satellite nations to embark on programs of their own.

After the Hungarian revolt, the Soviet Union also negotiated new bilateral economic agreements with the orbit nations. Under the terms of these agreements, satellite uranium continues to be shipped to the Soviet Union. For the first time, however, a "fair and mutually beneficial price" will be paid for the ore, but this money must be used for improving the mines.[69] As long as the satellite nations have no processing plants of their own, and their raw ore must be processed in the Soviet Union, they will be forced to accept Soviet terms of payment.

Another Soviet control measure, initiated in 1956 and expanded in 1957, was a system of bilateral agreements for scientific and technical exchanges between the Academy of Sciences, U.S.S.R., and its counterparts in the more advanced East European satellites. Such agreements have been signed with East Germany, Hungary, Poland, Rumania, and Czechoslovakia.[70] Exchanges between physics institutes in the satellite nations and certain Soviet physics institutes have been promised for 1958.[71] While seemingly meeting some of the objections to the Joint Institute voiced by scientists of the satellite nations, the new arrangement is very much in the interest of the Soviet Union in that it justifies the presence of Soviet scientists in the major institutes of the orbit nations. It will thus re-establish some of the Soviet control that was lost when, after the Hungarian events, the satellite nations forced the removal of some Soviet technical "advisors" stationed in their countries.[72] Henceforth, it will be difficult for any satellite nation's scientific research program, including work in atomic energy, to escape sharp Soviet scrutiny.

An exchange agreement has also been signed between the Soviet and the Chinese academies of science.[73] But it appears that the U.S.S.R. will have even more direct control over the development of physics in China during the next fifteen years, under the terms of an agreement signed between the governments of the two nations.[74]

The various Soviet efforts to meet the threat of uncontrolled atomic energy development within its orbit have so far been successful. The more advanced satellite nations have obtained certain concessions. To date, however, all peaceful atomic programs in the Soviet bloc are closely dependent on assistance from Moscow and can thus be kept under Soviet surveillance and control.

III. National Programs in the Soviet Bloc: 1956-1958

Despite delays, disappointments, and measures designed to insure Moscow's continued control of their atomic activities, nations in the Soviet orbit, particularly the more advanced ones, are still determined to develop domestic atomic programs. All are planning eventually to have atomic power stations. When the total lack of facilities for work in experimental physics prior to 1955 is taken into account, progress to date is impressive.

Slowly the initial Soviet sharing offers are being implemented, and several nations have secured promises of Soviet help in building atomic power stations. Some have started intensive programs to train future atomic specialists at home, and thus will gradually become less dependent on Soviet atomic aid.

Atomic energy development since 1955 has varied from country to country; differences in internal political and economic stability, in level of atomic sophistication, in degree of industrialization, and in the several nations' ability to exert pressure on the Soviet Union help to explain these variations.

At the moment, East Germany has the most advanced domestic atomic program, Czechoslovakia is second, and Poland's program is growing rapidly. Other orbit nations have made less progress; Albania the least of all.

East Germany

Several factors have worked to East Germany's advantage in her effort to catch up in peaceful atomic applications, and her program is developing rapidly. The quality and quantity of atomic raw materials supplied by the Soviet Union since 1946, the contributions of German scientists to the Soviet program during the crucial years immediately after World War II, East Germany's comparatively high industrial capacity, and the partial recovery of her precision-tool industry have been valuable assets.

After the war, the rich uranium deposits in Saxony were among the first to be exploited by the Soviet Union.[1] They are still operated by a joint Soviet-East German corporation, Aktiengesellschaft Wismut, and the entire uranium output is still sent to the U.S.S.R. However, in recent years the Soviet Union has paid for the ore,[2] formerly taken as a part of war reparations.

Important early work in nuclear physics was done in German universities until the 1930's. After Hitler seized power, many outstanding German physicists emigrated to the West, and little significant research on peaceful uses of atomic energy went on in Germany thereafter. A limited amount of research directed toward the military uses of atomic energy was carried out until Germany's defeat in World War II,[3] but this work has had little significant effect on the postwar development of peaceful applications in East Germany, primarily because what remained of equipment and personnel had been diverted to the U.S.S.R. during the Soviet occupation.

Soon after the war, the Soviet Union took the best scientists remaining in East Germany to the U.S.S.R. to work in the high-priority Soviet atomic program. Some of these, including Drs. Gustav Hertz and Manfred von Ardenne, have been permitted to return to East Germany in recent years. After a twenty-year interruption, a peaceful atomic program is being slowly rebuilt.

In 1955, shortly after the initial Soviet offer to build research reactors and cyclotrons for satellite nations, the East German government set up a Scientific Council for the Peaceful Use of Atomic Energy. Dr. Gustav Hertz is chairman of this group, which serves directly under the Council of Ministers

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and is the highest governmental policy advisory group on all aspects of the domestic atomic program.[4] The Scientific Council has set up subordinate commissions, which are responsible for formulating policy on such matters as problems related to isotopes, nuclear research instruments, radiation protection for personnel, the measurement of fallout over East Germany, training of new personnel, and legal and political questions related to atomic energy.[5]

The implementation of such policy, as well as operational problems connected with the East German atomic program, are the responsibility of the Office for Nuclear Research and Technology, also directly responsible to the Council of Ministers. This office controls isotope distribution, transport of radioactive materials, radiation protection measures, and fallout measurement. It co-ordinates long-range research planning for nuclear energy work. In addition, it supervises activities at nuclear research and training institutes and at factories manufacturing instruments used in nuclear research.[6]

Members of both the Scientific Council and the Office for Nuclear Research and Technology include outstanding physicists, many recently returned from the Soviet Union. Some physicists are members of both bodies, and there is some overlapping in the responsibilities of the two groups. Still another group,

the Advisory Council for Scientific-Technical Research and Development, was established under the Council of Ministers in mid-1957. Commonly known as the GDR Research Council, this unit is responsible for policy concerning all scientific and technical development in East Germany.[7]

Despite the complex and often overlapping functions of the governmental groups which control atomic energy activities, East Germany is taking steps to insure the rapid development of a peaceful atomic program. Plans are under way for a network of atomic power stations, but the necessary specialists to build and run these stations must first be trained. One authoritative spokesman has said that the East German atomic energy program will require at least 5,000 trained scientists by the mid-1960's. He adds: "We do not know where to get them."[8] Sending students for training in the Soviet Union will not supply those numbers. Since the fall of 1956, therefore, an intensive program to train applied nuclear physicists at East German institutes has been under way. Facilities for theoretical research have also been expanded.

Most atomic energy work is centered in Dresden and environs. A new Central Institute for Nuclear Physics is under construction at Rossendorf, near Dresden.[9] Under the direction of Professor Heinz Barwich, it will serve as both research and training center, and is under the direct control of the government's Office for Nuclear Research and Technology. After considerable delay, the central building has been completed, and the research reactor purchased from the U.S.S.R. went critical on December 16, 1957, about a year behind schedule.[10] The cyclotron purchased from the Soviet Union is being assembled at the Institute, and was to have been completed in mid-1958.[11]

Current plans call for the establishment of several other laboratories at the Central Institute. A laboratory for basic work in radiochemistry, isotope applications, and processing of radioactive materials is scheduled for completion some time in 1959.[12] Additional laboratories for applied atomic research will include a dosimetry lab.[13]

An important training center for future specialists in applied physics is located at the Dresden Technical College (Technische Hochschule). Both long-range and short-range training programs were inaugurated there in September 1956, and a Faculty of Nuclear Technology was established.[14] Three institutes function under this faculty: the Institute for General Nuclear Technology, the Institute for Experimental Nuclear Research, and the Institute for Theoretical Physics.[15]

The Institute for General Nuclear Technology has major responsibility for the long-range program, a five-year course

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to train nuclear engineers for East Germany's future atomic power program. The course includes work in the construction and applications of high-energy accelerators, in neutron physics, and in reactor theory.[16] An isotope laboratory is already in use, a 1.5 Mev betatron and a Van de Graaff generator were scheduled for completion in 1957, and construction of a 10 Mev betatron and other equipment is planned.[17]

The short-range training program consists of orientation courses lasting three to four weeks and designed to acquaint senior engineers and technicians from industries and technical schools throughout the nation with various industrial and power applications of atomic energy.[18] Plans call for an enrollment of 800 to 1,000 engineers and technicians annually in these orientation courses.[19] Similar short-range courses have been given by faculty members of the Technical College at such local installations as the Dresden power plant.[20] Well-known physicists teaching in both the long-range and the short-range programs include Drs. Wilhelm Macke, Heinz Barwich, and Manfred von Ardenne.[21]

Construction of another major training center, at Leipzig, was begun during 1955. Although plans call for several institutes to be built, the only one actually under construction so far is the Institute for Applied Radioactivity, which was to have

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been completed in 1957, and is designed to train chemists for the projected atomic power program.[22] Some work is being done at the Institute, primarily through short-range orientation courses,[23] but the completion of the center appears to be behind schedule.

Existing university training centers, especially those at Leipzig, Jena, and Rostock, are being expanded. Their emphasis is on training students to build betatrons, computers, cloud chambers, and other advanced tools necessary to atomic programs.[24]

A number of new isotope laboratories have already been established in industries, universities, and technical schools, and many more are planned. Several state-owned factories have begun to manufacture much of the equipment that these labs require, the two most important being the "Laborbau" and "Vakutronik" factories in Dresden. The former mass-produces much of the equipment needed to set up a "package" isotope laboratory in which to train students.[25] The "Vakutronik" factory, established solely to manufacture equipment needed for work with isotopes, went into limited production in September 1956,[26] and has steadily expanded since. Gamma counters, ionization chambers, impulse counters, and similar instruments are now being produced;[27] and work is under way on the designing of prototypes for mass-producible electromagnetic isotope

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separators, 4-Mev Van de Graaff generators, beta spectrometers, and small 30 Mev betatrons.[28] Export orders have been received from Poland, Rumania, and China,[29] and the factory is likely to become a major supplier of such instruments to these and other satellite nations.

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Although atomic energy activity in East Germany at present appears to emphasize training, the entire program is keyed to developing a network of atomic power stations as quickly as possible. Despite constant efforts to expand East Germany's conventional power network, the current industrial development, with its increasing drains on the power supply, continues to create power shortages. Moreover, the goal for expansion of conventional power sources was not met in 1957. In a recent speech to a government group, a high official of the State Planning Commission admitted that, even if goals for annual electropower expansion were met, there would continue to be power shortages, particularly during peak hours, until 1960.[30] To solve the problem, East Germany hopes to acquire economically feasible atomic electropower.

After talks in Moscow in mid-July 1956, the Soviet Union agreed to help build the first atomic power station in East Germany.[31] The U.S.S.R. has since furnished the necessary blueprints and materials, and is assisting East German scientists

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in building the reactor now under construction north of Berlin. The atomic power station is a pilot plant which, when operational, will be connected to the existing power grid. Scheduled for operation by 1960, it will have a pressurized water reactor fueled with natural and enriched uranium. The designed capacity is 200 to 250 megawatts heat and 70 to 100 megawatts electricity.[32]

East Germany's first atomic power station will serve three purposes. First, scientists and engineers working with the Soviet technicians will learn about power reactor construction and design in the course of building the station. Second, the plant, once it is operational, will serve as an experimental pilot station, enabling scientists to improve the design and incorporate these changes in future designs. Third, the station will produce a limited amount of electricity to help alleviate existing shortages.

As soon as possible after the first pilot plant is operational, East Germany plans to build a network of atomic power plants to produce economically feasible electricity. Current goals call for construction of several stations by 1965,[33] and for completion of a network of twenty such stations by 1970.[34]

Although they must look to the Soviet Union for help in building the first atomic power plant, the East Germans are

determined to create an independent nuclear power program. As one scientist has said, "a successful increase in the utilization of nuclear energy is possible only if we are able to create an atomic industry of our own, and if we are able to work creatively for its further development on the basis of the results of scientific research and experience."[35]

With an eye on the future, East German scientists are doing research on metals that can withstand high pressure and extreme heat -- essential components of nuclear power plants. As one scientist has pointed out, "materials important in nuclear technology, such as uranium, graphite, boron, beryllium, zirconium, cadmium, and others, must be produced. We need personnel who are familiar with these materials and can handle them. Problems relating to the conduction of heat and structural problems of all kinds will have to be solved in connection with our power stations."[36] Much of this research is being done at the Institute of the Physics of Very Pure Materials, in Dresden.[37]

As the East German atomic power network expands, it will become increasingly difficult for the Soviet Union to maintain strict control over the program. At present, the U.S.S.R. enjoys an important advantage: there is no isotope separation plant anywhere in its orbit outside the Soviet Union. East Germany, like other satellite nations, must send its raw ore

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to the Soviet Union for processing. Such plants are extremely expensive, and East Germany has no plans for building one in the near future.[38] For obvious reasons, the U.S.S.R. will discourage the construction of such plants. However, Dr. Gustav Hertz, now prominent in the East German atomic program, did significant work on isotope separation methods during the early 1930's. If the planned atomic power network is established without undue delays, East Germany will probably attempt to build her own isotope separation plant -- another step toward atomic independence from the U.S.S.R.

In the meantime, however, not only is East Germany dependent on Soviet isotope processing plants, but her used reactor fuel rods also must be reprocessed in the U.S.S.R. for lack of reprocessing facilities in East Germany. As plutonium-producing power reactors are built, this dependence will become another, increasingly important factor in assuring continued Soviet control. Moscow, therefore, is likely to try to prevent as long as possible the construction of any processing plants, either for enriching raw ore or for reclaiming spent reactor fuel rods.

East Germany is not a member of the United Nations, and consequently is not eligible for membership in the International Atomic Energy Agency (IAEA). Her petition to attend the first

general conference of IAEA, in October 1957, as an observer was denied. Soviet propaganda has supported IAEA membership for East Germany. Actually, however, if East Germany were to become a member of the agency, she would be entitled to request enriched uranium and reactor fuel rods through IAEA, thereby lessening her dependence on Soviet supplies. For this reason, if IAEA ever decides to admit non-U.N. members, it is doubtful that the Soviet Union would support East German membership.

East Germany is a member of the Joint Institute of Nuclear Research, and has some scientists working there on high-energy physics. However, the East Germans consider the work at Dubna secondary to building a strong peaceful atomic program at home.

It is improbable that East Germany can fulfill her ambitious plans for an atomic power network by 1970. However, at the present degree of economic stability, the nation is equipped to achieve its goal with less than ten years' delay. The program has been given high priority, and the need for electric power strengthens the motivation. The probability of significant future achievements, therefore, should not be discounted.

Czechoslovakia

Like East Germany, Czechoslovakia urgently needs new power sources. Its current atomic program is designed to train technicians so that an atomic power network may be established as soon as possible.

Czechoslovakia's Jachymov mines near Ostrov are a rich source of uranium ore, and their output compares favorably with that of East Germany.[39] Immediately after the war, they were taken over and exploited by the Soviet Union.[40] More recently, Moscow has been paying for the ore,[41] and operation of the mines has become a joint Soviet-Czechoslovak venture.[42] Under Soviet direction, the mines have been improved. In addition, there has been intensive prospecting for new deposits, and some of these are now being exploited.[43]

So far, scientists in Czechoslovakia have been more successful than their colleagues in other orbit nations in keeping governmental control of peaceful atomic research at a minimum. At one time, a government commission for peaceful uses of atomic energy was set up and functioned as a planning unit, but it apparently was abolished in June 1956.[44] Atomic energy research is centered at the institutes of the Czechoslovak Academy of Sciences, particularly at the Institute of Nuclear Physics. Some work is also being done in the laboratories of the Slovak Academy of Sciences, which has retained its separate organization, although the two groups co-operate closely. An intensive training program is going on, for which the universities have primary responsibility.

Prague is the focal point of atomic research and training.
The Institute of Nuclear Physics of the Czechoslovak Academy of Sciences, directed by Engineer Cestmir Simane, is located there and has been expanding steadily. Since 1955, a new series of laboratories to house it has been under construction along the Vltava River on the outskirts of Prague. The new laboratories are being built in several stages, the last to be completed in 1961.[45]

Eventually, the Institute will be a significantly well-equipped center for research and training in all aspects of peaceful uses of atomic energy. The first building, which houses the research reactor purchased from the U.S.S.R. and laboratories necessary to its use, has been completed. The reactor went critical on September 24, 1957, and is now in use.[46] A laboratory to house the cyclotron from the Soviet Union is under construction, and the cyclotron is scheduled to be put into operation in 1958.[47] Other equipment at the Institute includes a 1-Mev cascade generator purchased from Switzerland,[48] a beta-spectrometer, and two scintillation gamma-spectrometers.[49] A Van de Graaff accelerator and an improved beta-spectrometer are under construction.[50] A well-equipped isotope laboratory is in use; many of the instruments necessary for this lab were built in prototype in Czechoslovak research centers and are now beginning to be series-produced by Czech industries.[51] Research in all the laboratories is keyed to the future development of a Czechoslovak atomic power network. Describing the Institute's work, its director has said: "The main and most important task is the preparation of scientific data for the construction of Czechoslovak nuclear power plants, which in the not-so-distant future, in ten or fifteen years, will provide a considerable part of the electricity consumed.[52]

Until 1958, scientists at the Institute concentrated chiefly on construction of equipment. Nevertheless, creditable research was conducted also in experimental physics, and a number of papers in that field have been published.[53] A great deal of work has been done in nuclear spectroscopy. In addition, there has been emphasis on various aspects of radiochemistry, especially problems of disposal and decontamination of radioactive wastes and work with isotopes and tracer compounds.[54] Research on the biological effects of radiation is also being conducted.[55] Work on all aspects of reactor technology has enjoyed high priority,[56] and papers read by Czechoslovakian scientists at the Second International Conference on Peaceful Uses of Atomic Energy, in the summer of 1958, indicate that serious research on power reactor design is going on.[57]

In addition to the work of the Institute of Nuclear Physics, research is being done at the Institute of Technical Physics and the Physics Institute of the Czechoslovak Academy of Sciences.[58] Also, the Slovak Academy of Sciences in 1955 set up a commission, headed by Academician Landislav Ciganek, to plan for establishment of an atomic research center in Slovakia.[59] Lack of equipment so far has confined work in Slovakia to training programs in isotope applications and construction of a cosmic ray lab in the Tatra mountains.[60] But it may be assumed that the scope of the Slovak effort will broaden rapidly with the growth of the country's program for peaceful uses of atomic energy.

At present, the major training centers for atomic physicists at the college level are located in Prague. The most important of these is at Charles University, which established a Department of Nuclear Physics in 1955. That same year, a five-year course in nuclear physics and technology was inaugurated, in which students study engineering and atomic physics for two-and-a-half years, and thereafter devote full time to the study of nuclear engineering.[61] Many of the 180 students who enrolled the first year will graduate in 1960.[62] New laboratories for their training were reported to be under construction in 1956;[63] but students may also use the facilities of the nearby Institute of Nuclear Research.

Besides the five-year course, the Department of Nuclear Physics conducts one-year orientation courses in nuclear technology for engineers currently working in various Czech enterprises. Several groups have completed this course, which is held both at the University and near certain industrial installations.[64] The subject matter of the short course varies according to the field of specialization of the student group, since the idea is to train specialists for specific jobs connected with operating atomic power stations.[65]

An Industrial School of Nuclear Technology, offering a four-year course in reactor technology, radiochemistry, and electron physics, also opened in Prague in 1955, the only one of its kind in the satellite nations. Its graduates will work in factories manufacturing nuclear physics research tools and will service reactors. One hundred forty students enrolled the first year. A building for the school and its laboratories is scheduled for completion in 1958.[66]

One-year training courses, similar to the short-range training program conducted by Charles University, are being started elsewhere in Czechoslovakia. Brno University began such courses in 1955, and more than three hundred engineers and technicians have already taken them.[67] Similar courses were started by Komensky University in Bratislava in 1956.[68] Still more recent ones have been inaugurated by various industrial groups.[69] To supplement the intensive training program being conducted at home, some engineers -- at least fifty annually -- are still being sent to the Soviet Union for advanced training.[70]

Czechoslovakia is also building up industrial support for her expanding peaceful atomic program. Several Czech factories have begun to manufacture various kinds of relatively simple precision instruments necessary to nuclear research, including certain radioactivity counters, electric impulse counters, and tools for remote-control manipulation of materials in the "hot" labs around research reactors. Low-power betatrons, with a 2.5 Mev capacity, went into mass production in 1957. Prototypes for most of the instruments now in production were developed at the Research Institute for Vacuum Electrical Engineering, and principal instrument manufacturing to date has been centered at the "CKD-Stalingrad" plant in Prague and the "Metra" plant in Blansko.[71] The Klement Gottwald engineering plant at Brno supplied many supplementary steel parts for the new research reactor laboratory completed not long ago at the Institute of Nuclear Research.[72]

Until recently, industrial applications of isotopes in Czechoslovakia had been limited by shortages of isotopes, laboratory equipment, and trained personnel.[73] But increased domestic production of laboratory equipment and the fact that an isotope-producing research reactor is now in operation have accelerated the development of such industrial uses.[74] Applications of isotopes in the field of medicine also have increased.[75]

However, the Czech research reactor is considered, first and foremost, a training tool for future power reactor engineers. From the beginning, a network of stations that will produce economically feasible atomic power has been Czechoslovakia's primary goal. At the time of the first International Conference on Peaceful Uses of Atomic Energy at Geneva in 1955, Czechoslovakia was hoping to complete such a network by 1975.[76] Her coal supply was being drained by a growing industry, and the demand for electric power was expected to increase further at the rate of 10 to 15 per cent annually.[77] Power shortages have continued, and, despite delays, plans in 1956 still called for enough atomic power stations to meet one-third of Czechoslovakia's electricity requirements by 1970.[78] A recent article in a Czechoslovakian source predicts that about two billion kilowatt hours of electricity per year will be produced by atomic power plants in Slovakia and Moravia by 1965.[79] It is thought that, from 1970 on, atomic electropower will be able to provide for all increases in power needs.[80]

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Early in 1956, Czech sources began to refer to the fact that the nations's first atomic power station was under construction.[81] However, the project fell behind schedule as a result of technical difficulties.[82] Soviet help in building the station was announced under the terms of an economic agreement negotiated with the U.S.S.R. in January 1957.[83] Although construction of the power reactor itself did not begin until 1958, the station is still scheduled for operation in 1960.[84] Its site is in sparsely populated, heavily forested Slovakia, where a general program for industrial development has begun. The reactor will be fueled with natural uranium and moderated with heavy water, and has a designed electrical capacity of 150 megawatts.[85] The station will be a full-scale industrial atomic power plant, which will produce electric power to supplement the output from non-atomic plants. Original plans to build a pilot power reactor before constructing a full-scale industrial station were abandoned in order to save time and expense and to insure production of needed electricity at the earliest possible moment.[86]

With the experience gained in work on this first power station, Czechoslovak scientists hope to design and build future stations without Soviet help.[87] Present plans call for production, by 1965, of about 2 billion kilowatt-hours of economically feasible electricity from atomic power stations.[88] Significant

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research has been conducted on ways of reducing the cost of electricity produced in atomic power reactors, and Czech scientists have decided to concentrate on the development of fast-breeder reactor designs.[89] Research is also being done on metals necessary to power reactor construction, on safety measures, on disposal of radioactive wastes, and other problems.[90] A new laboratory to study diseases caused by radiation is under construction at the Biophysical Institute of the Czechoslovak Academy of Sciences, at Brno.[91] It is to be completed in 1959.[92]

Czechoslovakia would like to build an isotope-processing plant and a factory to manufacture heavy water,[93] thereby making her atomic power program as autonomous as possible. However, it is unlikely that the Soviet Union will permit such plants outside the U.S.S.R. In addition, the expenses of such construction would be a heavy drain on the Czech economy.

Like those of East Germany, Czechoslovakia's ambitious plans for an atomic power network by 1970 are already behind schedule. But her growing power needs supply an incentive for continued endeavor, and the present intensive efforts are bound to yield results. Unlike East Germany, Czechoslovakia is a member of IAEA and, if necessary, can obtain some assistance from that organization. The Czech program seems to be catching up with East Germany's, and atomic power will undoubtedly be a major source of energy in Czechoslovakia by 1980.

Poland

Poland is another country determined to build an independent peaceful atomic program, and her primary effort currently is geared to training the personnel who will operate a future atomic power network. However, Poland is not as highly industrialized as East Germany or Czechoslovakia, and her immediate problems are greater and more numerous. Consequently, the Polish program is developing somewhat more slowly than those of her neighbors.

Poland's uranium mines in Lower Silesia have supplied ore to the Soviet Union since the war. Like other orbit nations, Poland has been paid for her uranium in recent years. But the yield from existing mines was rather limited, both in quality and in quantity, and in 1956 Polish scientists began searching for new uranium. By the end of 1957, they had discovered deposits three times as large as those being mined.[94] Lacking the funds and trained experts for independent exploitation, Poland was forced to turn to the U.S.S.R. for help. After talks in Moscow, an agreement was signed on January 22, 1958, providing for joint Polish-Soviet mining and processing of the new ores. Poland will pay for the help with credits that exist under her general trade agreement with the U.S.S.R.[95]

The chief policy-making unit on matters concerning peaceful atomic development is the Polish State Council for Peaceful Use of Atomic Energy, established in August 1956 and responsible to the government presidium.[96] Its chairman is Wilhelm Billig.[97] A few months before the State Council was established, Billig had been named Government Plenipotentiary for Peaceful Use of Atomic Energy.[98] The functions of these two posts overlap considerably, but the office of Government Plenipotentiary seems to carry more operational responsibilities than the chairmanship of the State Council. The latter, in addition to its policy-advisory functions, is responsible for co-ordinating long-range planning in the atomic field and for supervising work at research and training institutes. Its membership includes representatives from the Polish Academy of Science and key government ministries.[99]

Despite governmental encroachments, the Polish Academy of Sciences still plays a leading role in the effort to develop a strong domestic program for peaceful atomic uses. The Academy resents the growing government control over scientific planning and development, especially in the field of atomic energy, and has made efforts to safeguard its position as the most important center of scientific activity.[100] However, like its counterparts in other countries of the Soviet orbit, the Polish Academy seems to be losing its traditional authority to governmental groups.

A Council for Technical Affairs, responsible to the Council of Ministers, was established late in 1957, and now advises the government on all questions of scientific and technical development.[101] Like the State Council and the office of the Government Plenipotentiary for Atomic Energy, it has taken over some of the scientific planning functions formerly exercised by the Academy.

Nevertheless, the principal research and training centers of the Polish atomic program ostensibly are still under the jurisdiction of the Academy of Sciences.* In July 1955, the Academy established an Institute of Nuclear Research,[102] with one of its two branches located at Bronowice near Krakow, and the other at Swierk near Warsaw. Warsaw University and Jagiellonian University at Krakow, the Polish centers for study and research in physics before the war, both have begun to expand their courses in physics and to rebuild laboratories that were partly destroyed during the war. Having the Institute's laboratories near Warsaw and Krakow will enable university students to use the Institute's equipment.

Both the Krakow and the Warsaw laboratories of the Institute are still under construction. Buildings for them having for

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* The corresponding institutes in East Germany are under direct government control.

the most part been completed, scientists now are concentrating on the construction of research instruments. A few theoretical papers have already been published, and the Institute has sent representatives to scientific conferences abroad.[103] Both the cyclotron and the research reactor that were promised Poland by the U.S.S.R. in 1955 are located at the Institute. Unrest in Poland in 1956 and other factors delayed their completion, and the research reactor did not become operational until June 1958.[104] The cyclotron began to operate at the end of 1958.[105]

When the two branches of the Institute are completed, they will concentrate on training specialists in applied nuclear physics, in a course of study that will emphasize problems related to the operation of atomic power stations. Work at the two branches of the Institute will be quite similar, although the Warsaw branch will do more than the Krakow center in the fields of materials testing, reactor technology, and isotope applications.

The cyclotron from the Soviet Union is being assembled at the Krakow branch.[106] In 1956, after four years of effort, Polish scientists at Krakow completed a Van de Graaff accelerator and an ion accelerator, and began to build a small cyclotron in addition to the one purchased from the U.S.S.R.[107] Construction

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of these research tools was directed by Professor Henryk Niewodniczanskiy, who is both director of the Krakow lab and head of the physics department at Jagiellonian University.[108]

The research reactor from the Soviet Union is in operation at the Warsaw laboratory.[109] Polish scientists there have built additional research instruments of fundamental importance, including a Van de Graaff accelerator.[110] Since 1956, the laboratory has conducted short-range orientation courses designed to acquaint engineers and scientists from various branches of Polish industry with problems of applied nuclear physics.[111] Courses have also been given in the use of isotopes.[112]

The Institute of Nuclear Research is responsible for technical problems connected with constructing an atomic power network in Poland.[113] Reportedly, a laboratory has been established for work in this area, which is said to be headed by Professor Z. Klemensiewicz, a physicist recently returned from Britain.[114] No details are available.

Several isotope laboratories have been set up in Poland, although isotope application has not proceeded as quickly as in East Germany.[115] Also, a Central Laboratory for Radiological Protection has been established within the Polish Academy of Sciences to conduct research on safety measures, radioactive waste disposal, and similar problems.[116]

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Colleges and universities are slowly intensifying their training courses in applied physics, and expanded curricula are being instituted in the colleges of Science and Technology at Warsaw, Wroclaw, and Gliwice, as well as at the universities of Warsaw and Krakow.[117] However, as in prewar years, shortages of research equipment continue to retard the development of an intensive training program in experimental physics. Within the next few years, however, Poland expects to establish factories, similar to those now operating in East Germany, to manufacture counters and other basic laboratory equipment. Soviet assistance in this venture was promised under the January 1958 agreement.[118] Protocols signed with East Germany and Czechoslovakia provide for assistance from both countries in the design and construction of prototypes for mass production of basic laboratory equipment.[119] From the U.S.S.R., Poland will also receive a second research reactor, as well as assistance in building an experimental atomic power station.[120]

Besides improving the facilities for intensive training in experimental physics at home, Poland is sending students of atomic physics abroad for further study. Many go to the Soviet Union, but some are studying in the West. The government official most closely connected with the Polish atomic program recently stated that twenty atomic specialists were currently in the West for long-range training.[121]

The center of research in theoretical physics -- traditionally the most advanced branch of physics in Poland -- has been the Institute of Theoretical Physics of the Academy of Sciences, at Warsaw. Under the direction of Professor Leopold Infeld, who returned to Poland from Canada in 1950, the Institute is carrying out an intensive training program, closely co-ordinated with the curriculum of Warsaw University.[122]

Poland has a better supply of coal than East Germany, but she is equally determined to have an atomic power network, and plans to divert coal supplies to other uses as atomic electro-power becomes economically feasible.[123] Although economic and political disruption have forced the Poles to revise their original time schedule, all nuclear energy work is still being directed toward that same goal. According to current plans, the prototype atomic power station, which now is to be built with Soviet assistance, will be in operation by 1965, and a small network of stations, with a total electrical output of 600 mega-watts, should be established by 1970.[124]

Work on metals essential to atomic power reactor construction is also under way.[125] Poland wants to establish her own ore-processing plants,[126] and in 1957 a team of experts was appointed to examine the feasibility of such a project.[127] Although the January 1958 atomic assistance agreement between Poland and the

U.S.S.R. mentions Soviet help in the processing of Polish ore,[128] it is unlikely that Moscow will permit an isotope-processing plant to be established in Poland.

Poland, however, is unique among the nations of the Soviet orbit in not depending solely on the Soviet Union for peaceful atomic assistance. Contact has been established with individual Western physicists, many of whom have been invited to visit Poland's atomic research centers since early in 1957. Talks on peaceful atomic co-operation have been held with France,[129] and already there has been a limited exchange of specialists and advanced students.[130] Part of a Rockefeller Foundation grant of almost half a million dollars for Polish scientific development reportedly is being used to train atomic specialists in the West and to purchase research equipment.[131] Preliminary discussions on peaceful atomic co-operation have been held with Sweden and Norway.[132] An agreement on Polish-Yugoslav co-operation in the peaceful uses of atomic energy was signed early in April 1957, and the possibilities of further co-operation are being negotiated.[133] Polish physicists are extremely anxious to have some of their American colleagues spend a year or two in Poland assisting them.[134] A member of IAEA, Poland has applied to the U.N.-sponsored agency to help fill two staff vacancies at the Warsaw branch of the Institute of Nuclear Research with qualified scientists from abroad.[135]

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Polish physicists, in turn, have attended scientific conferences in the West, and have visited Western research installations in Great Britain[136] and elsewhere. An American scientist reports being told by some of his Polish colleagues that they have a high respect for Western atomic achievements, and would prefer help from the West to Soviet assistance.[137] However, the Polish regime realizes that contacts with the West in all fields must be kept within limits as long as Poland remains part of the Soviet bloc. The broader aspects of Polish relations with both the Soviet Union and the West make it unlikely that Polish atomic physicists will be able to extend their collaboration with Western colleagues to any significant extent.

Despite past and present difficulties, the years 1958-1960 should mark a turning-point in the development of peaceful atomic uses in Poland. New economic agreements signed with both Moscow and Washington are helping to alleviate Poland's economic crisis. As the general economy improves, Poland will be in a better position to carry out her ambitious plans in the atomic field. Undoubtedly, it will be difficult to complete a small atomic power network as early as 1970. However, if the present level of economic and political stability is maintained, atomic electropower may well be an important energy source in Poland by 1980.

China

For several years, Communist China has recognized the importance of a domestic atomic energy program. Uranium deposits and other necessary raw materials are available, and in 1950 a joint Sino-Soviet firm apparently was set up to mine the uranium.[138] The Chinese economy is still too backward, however, and technical personnel too scarce, to support an independent atomic program, and China, therefore, will need considerable assistance from the U.S.S.R. if she is to build up a meaningful atomic energy program. But the entire Sino-Soviet relationship is more complex than any between Moscow and the East European satellites, and the question of how much atomic assistance the Soviet Union will be willing to render China is closely related to the broader aspects of that relationship. The Soviet Union included China in its initial peaceful atomic sharing offer, and in 1958 there were unconfirmed reports that the U.S.S.R. had agreed to supply more atomic reactors, as well as atomic weapons, to China.[139] Opinions differ, however, on the extent of the military or peaceful atomic assistance that the Soviet Union is actually prepared to give, and paucity of information on this score restricts Western analysis of the problem.

Ever since the Communists gained control, in 1949, there has been an intensive effort to industrialize China. For a number of years, there was heavy reliance on Soviet assistance. Countless young Chinese scientists and technicians were sent to the U.S.S.R. for advanced training; many technical advisors from the Soviet Union were at work in China.

During 1956 and 1957, there were indications that the Chinese were making efforts to rely less heavily on technical assistance from Moscow and to develop their domestic resources more extensively.[140] Late in 1957, however, internal ideological controversies, extreme shortages, technical problems, and other factors brought a return to greater dependence on Moscow. In particular, China's ambitious project for scientific development in key fields, including atomic energy, now appears to be a joint Sino-Soviet venture.

Events since early 1956 illustrate the fact that the development of an atomic energy program in China is more closely related to broader problems of political ideology than is the case in other orbit nations. There is evidence that China is experiencing the complex ideological and technological growing pains that are common to all Communist states in the early stages of "building socialism."

A directive issued late in 1955 reflected a governmental decision to launch a broad program for improving Chinese science in general, and correcting inadequacies in the development of certain particular fields, including physics. High priority was to be given the development of peaceful uses of atomic energy. According to the directive, the next fifteen years would be a crucial period for the Chinese economy, since, by 1970, China was to be transformed into a "strong socialist state" with a powerful heavy industry, a modern defense industry, and improved light industry, agriculture, and transport. Chinese science, so weak at present, was to use that period to come up to world standards, and the Chinese Academy of Sciences was to have primary responsibility for the success of this scientific effort.[141]

A month later, the target date by which Chinese science was to catch up with the rest of the world was advanced to 1967. Meetings of senior scientists were called to discuss the formulation of what became known as the "Twelve-Year Plan for Science."[142] Throughout 1956 and 1957, Chinese scientists spent little time in their laboratories and much time in discussion.

Debates on the twelve-year plan soon became open forums, where scientists aired all their complaints, argued ideological questions, and charged that any master plan for science would restrict free research.[143] Many of the complaints were justified. Personnel shortages were acute. In addition to their research,

teaching, and planning functions, leading Chinese scientists were expected to do a certain amount of political work, and to cope, also, with time-consuming administrative details. In 1957, department heads within the Chinese Academy of Sciences sought a guarantee that in the future they would be sufficiently relieved of extraneous tasks to be able to devote five-sixths of their time to research.[144] The President of the Academy replied that he would try to help in individual cases, and reminded his fellow scientists that the situation had improved in the preceding two years.[145]

Knowing their work to be essential to the government's program not only for science but for the national economy, the Chinese scientists felt entitled to privileged treatment. The government had already made certain concessions, but in a Communist state the Party must exercise a certain degree of control over scientific research. In China, the situation is further complicated by the fact that the majority of scientists are not Communist Party members.[146] Also, many of them received their training in the West and have retained some Western ideas and a pro-Western attitude. Despite the risks involved, however, the government at that time was following a new policy of greater freedom in the relationships between Party and non-Party groups, particularly among intellectuals and scientists.

This new governmental approach had first become apparent late in 1955, and the criticisms and complaints aired by scientists during the initial discussions on the "Twelve-Year Plan for Science" thus had official government sanction. Already Mao's policy of "letting a hundred schools of thought contend," not widely publicized in the West until more than a year later, was the official Party approach to certain circles of the Chinese scientific community.[147]

As discussions on the scientific plan continued, the complaints of scientists became more vigorous and more directly related to broader problems of the role of government in scientific planning. It soon became clear to government officials that, in scientific circles, "letting all schools of thought contend" was going too far.

In 1957, therefore, non-Party groups in general, and scientists and intellectuals in particular, were made aware once more that the Chinese Communist Party would tolerate no challenge to its rights to political leadership. Some time in July 1957, the so-called "rectification campaign," which had been in effect for some time, was extended from Party to non-Party circles.* The new offshoot of the "rectification"

* As originally conceived, the "rectification campaign" was an attempt to bring ideological ferment within the Chinese Communist Party under control. It was motivated by complex factors beyond the scope of this discussion.

campaign was an "anti-rightist" campaign, directed at non-Party deviants. At first, the attacks on "rightists," especially among the intellectuals and scientists, were mild; they consisted of exhortations to correct past ideological errors and to understand and accept the role of the Party in supervising and planning science. Later, there were instances of more extreme measures, and some scientific leaders were removed from key posts on the charge that they were "rightists."[148]

The "anti-rightist" campaign had two significant effects on Chinese science. First, it demonstrated to scientists that, despite their privileged position, there was a limit to the degree of freedom the political leaders would permit them. Second, it further delayed the implementation of China's "Twelve-Year Plan for Science." In mid-1957, the President of the Chinese Academy of Sciences admitted that "great efforts have to be exerted if the plan is to be translated comprehensively into reality and if the Chinese sciences, particularly the most important and weakest branches of science, are to approach or to catch up with the international level within the anticipated period."[149]

Other policy shifts directly affecting the future of Chinese science became apparent later that year. By the end of 1957, the Chinese had recognized that the goals set for

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their industrialization program had been far too ambitious; failures and delays were apparent in many branches of the economy. There were signs of renewed dependence on the Soviet Union. In addition to the lack of success in implementing the "Twelve-Year Plan for Science," there were other motivations for China's renewed bid for technical assistance from the U.S.S.R. First, the Soviet Union had demonstrated its scientific competence more strikingly in 1957 than ever before, and the development of a Soviet ICBM and the launching of Soviet earth satellites had had their impact on the Chinese. Second, the Soviet Union itself was making efforts to re-establish the economic interdependence of the countries within its orbit. Finally, the Communist orbit had to some extent recovered from the adverse economic effects of the events in Hungary and Poland in 1956.

Late in 1957, a large delegation of scientists, headed by the President of the Chinese Academy, spent three months in the Soviet Union negotiating an agreement for co-operative scientific research. The agreement, signed on January 18, 1958,[150] seems to make China's Twelve-Year Plan for Science a joint venture in key fields, including physics and peaceful uses of atomic energy. In the implementation of the plan, a highly-placed government group, the Scientific Planning Committee of the State Council, will work closely with its Soviet counterpart, a commission directly responsible to the Council of Ministers of the U.S.S.R.[151] Thus, the major responsibility for executing the plan now lies with the government, and more rigid control over the Chinese Academy of Sciences will be exercised. Whether Chinese scientists like it or not, the maxim "learn from all sciences, both East and West," which enjoyed brief official approval, has again become a meaningless phrase in China.

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Even if the U.S.S.R. gives China extensive technical assistance, considerable effort will be required if China is to develop a meaningful peaceful atomic energy program by 1970. The limited amount of physics research which has gone on since the Communists gained control in 1949 has been theoretical and comparatively elementary. As early as 1953, Chinese physicists recognized that their primary task was to "lay the foundations for the study of nuclear physics."[152] But shortages of equipment and personnel forced them to concentrate instead on other elementary problems of applied physics. Research in the physics of solids, particularly applications to metallurgy and crystallography, has been emphasized.[153]

Most physics research has been concentrated in the institutes of the Chinese Academy of Sciences, which include the Institute of Atomic Energy (Peking), the Institute of Applied Physics (Peking), and a Physics Laboratory at the Institute of Metal Research.[154] A limited training program for young physicists is being conducted in the universities. Peking University, the major center of this activity, will open a new, expanded physics laboratory in 1958.[155] Some work is being done at other universities, such as Chekiang, but up to the present the severe shortages of basic research tools hamper the inauguration of any large-scale training program and retard research efforts. The majority of young students still are sent to the Soviet Union for training. Scientists have complained that frequently these students are not qualified to use the opportunity to best advantage, and that there are long delays between the time a student arrives abroad and the time he actually begins to study.[156]

Chinese physicists have published only a few papers, but these show that they are well informed about relevant published work done in both the Soviet Union and the West. The lack of basic research tools has stimulated attempts to work out new methods. For example, a paper published in 1957[157] describes the method by which a scientist derived the masses of nuclei without recourse to mass spectroscopic results. The mass spectrograph has been a basic research tool in the West since long before World War II, yet this Chinese physicist had to work out a procedure of statistical adjustment to compensate for his lack of one. Two other scientists were able to carry out an experiment with practical applications in the metallurgical industry only after an institute in the Soviet Union supplied a special type of crystal plate essential to its completion.[158] An earlier experiment, on spontaneous fission of uranium, designed to supplement previous work done in the Soviet Union and the West, had had to be abandoned in the first stage, because no separated uranium isotopes were available, and the full experiment could not be conducted with natural, unenriched uranium.[159]

The shortage of senior personnel is as acute as that of research tools. In response to intensive appeals, a few Chinese physicists have returned from the West and are enjoying privileged treatment,[160] but a larger number have paid no attention to pleas for their return. Among those who have come back is Dr. Chang Wen-Yu, now working at the Institute of Physics, Chinese Academy of Sciences.[161]

Despite all these obstacles, Chinese physicists in 1957 made a slow start toward a peaceful atomic energy program. Several elementary training instruments were built: an electrostatic generator, a voltage multiplier, and a beta-ray spectrometer.[162] Extraction of pure uranium and thorium from

Chinese ores on a laboratory scale was reported.[163] Radioisotopes were being used to a limited extent for research in geology, metallurgy, medicine, and other fields.[164] Plans were made by which the industrial applications of isotopes were to be increased considerably during the next five years.[165] New nuclear physics training centers were in the planning stage.[166] As of mid-1957, ten Chinese scientists were doing significant research in high-energy physics at the Joint Institute at Dubna, U.S.S.R., and the institutes of the Chinese Academy of Sciences were being urged to recommend further candidates for work at Dubna.[167] The research reactor and the cyclotron that the U.S.S.R. had promised China in 1955 did not begin operation until mid-1958.[168] Subsequently, they were formally inaugurated in an elaborate ceremony attended by high-ranking Chinese government officials and an official Soviet delegation.[169]

As mentioned before, there have recently been unconfirmed reports that the U.S.S.R. has agreed to supply China with four more atomic reactors -- presumably including power reactors -- as well as with atomic weapons. Conjectures differ as to how much military or peaceful atomic assistance the Soviet Union is actually prepared to give China. But it seems reasonable to assume that the answer revolves around the degree of control

the Soviet Union will want to exercise, and will be able to exercise, over any advanced atomic equipment supplied to China. The possibility should be kept in mind that China today may be in a more favorable position than other nations of the Soviet orbit to bring effective pressures to bear on the U.S.S.R. An advanced atomic power network in China could improve China's economy, heighten her prestige in Asia, and thus support other long-range goals of Sino-Soviet policy. If Soviet control were not maintained, there would be some danger of China's using a peaceful, or a military, atomic capability acquired from the Soviet Union in a manner not intended by the U.S.S.R. On the other hand, there have been indications within the last year of a new interdependence in the complex over-all relationship between the two countries. Perhaps the Soviet Union has agreed to supply extensive atomic assistance to China in return for Chinese support of other Soviet policy goals. For the moment we lack the data necessary to prove such a hypothesis.

If, in fact, the Sino-Soviet relationship has reached a stage where the U.S.S.R. regards China as more genuinely a political partner than a satellite nation, China can be assumed to be in a position to demand, and to receive, more extensive atomic assistance than that supplied the East European satellites. A long-term goal of the Chinese Communist leaders has been to increase China's role as the leader of the Asian Communist movement and to be a partner, not a satellite, of Moscow. Great importance is attached to maintaining a strong military posture in Asia, and there is little doubt that the Chinese would like to have atomic weapons. However, whether the Soviet leaders have the guarantees necessary to assure them that China will continue to act in the Soviet interest is open to question. If they foresee any danger of China's opposing their long-range policy as she becomes industrially and technically more advanced, the Soviet leaders, should they agree to allow important atomic installations in China, would probably insist that they be under U.S.S.R. control. Whether and for how long they succeed in retaining such control would then, in turn, depend on whether China is able to exert enough pressure on the U.S.S.R. to force concessions.

Even if major atomic installations in China -- peaceful or military -- were to remain under Soviet control, it would be to the political advantage of both China and the U.S.S.R. if it appeared to the outside world that the Chinese controlled them. Such a compromise between what the Chinese appear to be demanding and the presumable desire of the Soviet Union to protect itself against the possibility that the Chinese might some day use their nuclear capabilities in ways contrary to

Soviet interests strikes this author as the likeliest of possible future developments.

Western observers lack the data that would tell them reliably whether or not the U.S.S.R. has promised to help China build atomic power reactors. Although the ambitious Twelve-Year Plan for Chinese Science is behind schedule, the Chinese eventually will want an atomic power network, despite the existence of untapped hydropower sources. Package power reactors with relatively low electrical capacity could be used to advantage in China, especially in remote areas. As the industrialization of China continues to progress, and as the high priority assigned to building up a peaceful atomic energy program alleviates shortages of trained personnel and research equipment, China will probably begin to build an atomic power network with Soviet assistance. Such a network may or may not remain under the control of Soviet personnel; even if it does, both China and the U.S.S.R. will probably recognize the advantage of having it appear to be under Chinese control. Developments in China's peaceful atomic energy program, which is just beginning to solve some of the countless problems that have delayed progress in the past, can be expected to take a significant upward turn within the next decade, especially in view

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of the rapid pace at which the industrialization of China appears to be progressing.*

Hungary

Having only limited supplies of coal and oil and virtually no hydroelectric power, Hungary wants atomic power stations that will be able to meet the electricity requirements of future industries. However, political unrest and the 1956 revolution and counterrevolution seriously delayed Hungary's efforts to start a peaceful atomic program.

Rich deposits of uranium were discovered near Pecs in southern Hungary some time in 1954. Mining began under Soviet control, and some ore had been shipped to the Soviet Union before the outbreak of the 1956 revolution.[170] Around November 1, the revolutionists seized the mines.[171] During the skirmishes which followed, there were conflicting reports on the degree of damage inflicted on the work sites. Even if the shafts were not dynamited, as some reports claimed, acute power shortages and the fact that many miners fled brought production to a standstill.[172] After the revolt had been quelled by Soviet troops, new agreements were signed with Moscow, under which

* Adlai E. Stevenson, for example, reports being told by N. S. Khrushchev in mid-1958 that the industrialization of China is proceeding with an astonishing rapidity unforeseen even by the Chinese themselves. (New York Times, October 2, 1958.)

Hungary ostensibly was to retain what ore she needed for use at home and sell the rest to the U.S.S.R.[173] However, Soviet help has been needed to rehabilitate the mines, and Hungary has no facilities for processing her raw ore. Limited mining was resumed in mid-1957, and it seems safe to assume that all ore is currently being shipped to the U.S.S.R. Joint Hungarian-Soviet prospecting for new uranium deposits also began about the middle of 1957.[174]

A government committee to expedite the development of a peaceful atomic program had been established under the Hungarian Council of Ministers early in 1956.[175] Its work, however, was also impaired by the political unrest, and the committee did not resume its functions until after its reorganization in the fall of 1957.[176]

Considerable ideological ferment within the Hungarian Academy of Sciences was another consequence of the 1956 revolt.[177] Although Communist control has since been re-established, previous plans for expanding some of the Institutes with a view to more extensive research in the field of peaceful atomic applications have been postponed indefinitely.[178] Members of the Academy are fighting for a more significant role in scientific and technological planning, but policy decisions in this sphere are now made almost unilaterally by government officials.[179]

Even prior to the 1956 revolt, several factors retarded Hungarian efforts for more intensive research in physics. Before World War II, work in theoretical physics had been on a very limited scale. Lack of equipment had prevented any major advance in experimental physics, and after the Nazi occupation most physicists fled Hungary to work in the West.[180] When a Central Physics Institute was set up under the Hungarian Academy of Sciences in mid-1950, scientists literally had to "start from scratch" on a program to train experimental physicists, the principal task assigned to the new Institute. In 1952, a department of atomic physics was established within the Institute.[181] When such serious obstacles as the shortage of equipment and trained personnel are taken into account, the growth of the Institute prior to the 1956 revolt can be considered impressive. By 1955, an isotope laboratory had been completed and was doing work with isotopes supplied by the Soviet Union.[182] Research was being conducted on elementary particles, and two small accelerators had been built under the direction of Karolyi Simonyi, head of the atomic physics department.[183] A new 5-Mev linear accelerator and a 600 kilowatt cascade generator were under construction.[184] Work in cosmic rays, nuclear spectroscopy, and various aspects of theoretical physics was in progress,[185] and the research reactor purchased from the

U.S.S.R. was being assembled at the Institute's laboratories on the outskirts of Budapest.[186]

Work on the reactor was halted by the 1956 revolt and not resumed until late in 1957.[187] Even then, shortages of material and laborers caused further delays in the assembling, but the government assigned high priority to its completion,[188] and the reactor was scheduled to go critical in the fall of 1958.[189] Since the domestic training program in experimental physics has been slow getting underway, the technicians to operate the reactor were trained in the U.S.S.R.[190]

Dissention and conflict within the Central Physics Institute during the 1956 unrest caused some administrative reorganization, and Academician L. Janossy, a cosmic ray expert who returned to Hungary after working in the West for thirty years,[191] replaced Istvan Kovacs as its director.[192]

At the moment, the most significant aspect of Hungary's domestic atomic activity is a training program for the wider use of isotopes in industry and agriculture. Several isotope labs have been built;[193] the principal one outside the Central Physics Institute is at the Debrecen Physics Institute, which was established in 1954 and concentrates on work with isotopes.[194] Director of the Debrecen Institute is Academician Sandor Szalay.[195]

Power shortages in Hungary became more acute than ever after the destruction and disruption caused by the 1956 revolt, and the need for atomic electropower has increased correspondingly. The Soviet Union has agreed to help Hungary build atomic power plants at some unspecified time in the future,[196] and the Hungarian government hopes to start construction on a network of stations during the 1960's.[197] Renewed efforts are also being made to widen and improve the domestic training of experimental physicists. In 1957, the University of Budapest established a Department of Atomic Physics and announced plans for such a training program.[198] A governmental committee studied the training programs of other nations, and by the fall of 1958 a broadened program for the training of atomic physicists had been formulated.[199] Papers by Hungarian scientists on certain aspects of reactor design were read at the Second International Conference on Peaceful Uses of Atomic Energy in 1958, indicating that some theoretical research in this field has been done even though Hungary has yet to complete her first atomic reactor.[200]

Despite the expense of equipping the requisite factories, Hungary has been anxious to begin manufacturing some of the less complicated instruments used in nuclear research, particularly those necessary to work with isotopes.[201] Again, the disruption of the economy after 1956 delayed the realization of these plans.

Hungary's peaceful atomic program is proceeding slowly, and it is most unlikely that she will complete an atomic power network by 1970. Her first requirement will be an effective training program that will produce the operators and engineers for such stations. What is more, the Soviet Union's reluctance to allow atomic power stations in Hungary was intensified by the temporary loss of political control in 1956, and Moscow probably will make every effort to prevent Hungary's atomic program from progressing beyond a stage where control can be easily maintained, and to confine it instead to increased isotope applications, low-level training programs in the universities, and work with the research reactor. Hungary will have to reach a much greater degree of economic and political stability than the present before she can hope to realize her dream of an industrial system powered by atomic energy.

Rumania

Rumania has limited coal deposits, but good supplies of oil and an untapped potential of hydroelectric power. Nevertheless, she has embarked on a training program in peaceful uses of atomic energy, and hopes eventually to have her own atomic power stations.

In the last few years, there has been intensive prospecting for uranium. Some deposits have been discovered and are being exploited,[202] but it would be difficult to assess either the quality or the quantity of the ore.

In 1955, a government committee, similar to those responsible for policy on peaceful uses of atomic energy in other satellite nations, was established under the Council of Ministers.[203] Most research work, however, still goes on in the Institutes of the Rumanian Academy of Sciences. An Institute of Nuclear Physics was established by the Academy that same year, under the direction of Academician H. Hulubei. It absorbed most of the former Institute of Physics, which had emphasized theoretical work.[204]

New laboratories for the Institute of Nuclear Physics are under construction on the outskirts of Bucharest, near the Neajlov River. In addition, an old castle at the site has been converted into laboratories that are already in use.[205] A new laboratory houses the research reactor, purchased from the Soviet Union, which went critical at the end of July 1957.[206] However, there is a shortage of Rumanian nuclear physicists, and many Soviet engineers apparently have remained at the reactor laboratory and are serving as instructors in the Institute's training program.[207] The cyclotron supplied by the U.S.S.R. went into operation at the Institute in January 1958.[208]

A cosmic ray laboratory has also been completed. So far, Rumanian scientists have concentrated on building research equipment. As of 1957, an experimental 30-Mev betatron and a Van de Graaff accelerator were under construction,[209] but an isotope lab for the Institute had yet to be built.[210] In the rush to recruit young trainees, many were selected who turned out to have no aptitude for science; and there has been some evidence of rivalry between the theoretical physicists working elsewhere and the experimental physicists at the Institute.[211] Steps seem to have been taken to improve the situation, but it will be some time before the Institute is sufficiently well equipped and staffed to fulfill its avowed task of serving as a research center "for finding the best way for Rumania to establish atomic electric-power stations."[212]

Many young atomic physicists are still sent to the Soviet Union for advanced training,[213] but special one-year orientation courses have been set up at Parkhon University in Bucharest for engineers and chemists now working in Rumanian industrial enterprises.[214] The use of isotopes in the oil and metallurgical industries, in agriculture, and in medical research is expanding with the growing supply of laboratory equipment and trained personnel.[215]

For the moment, Rumania is closely dependent on assistance from Soviet technicians and on training facilities in the U.S.S.R. However, as a member of the International Atomic Energy Agency she may hope to obtain assistance from that organization in the future. Late in 1957, it was announced that Rumania would attempt, through IAEA, to obtain foreign specialists for work at the Rumanian atomic research institute.[216] However, the Soviet Union undoubtedly would object strongly to such an arrangement, and can be expected to make every effort to keep the Rumanian atomic program dependent on Moscow.

There have been rumors of a Soviet promise of assistance in building atomic power stations in Rumania during the 1960's, but Moscow has made no official announcement to that effect. Given her present state of atomic training and equipment, Rumania will hardly be in a position to demand atomic power stations at such an early date.

Bulgaria

Six months elapsed before the initial Soviet sharing offer was extended to include a research reactor and a cyclotron for Bulgaria. This fact probably indicates that Bulgarian mines had yielded relatively little uranium for shipment to the Soviet Union after World War II.[217]

An Institute of Physics was set up within the Bulgarian Academy of Sciences in 1947.[218] However, its research facilities still are extremely limited. As recently as 1954, work at the Institute was confined to theoretical research at the college level and to some experimental work in cosmic rays, nuclear spectroscopy, and similar areas.[219]

The Soviet Union's decision to include Bulgaria in its peaceful atomic sharing offer gave rise to grandiose plans for constructing an atomic research center near Sofia, which eventually was to have twenty-three buildings, including laboratories, offices, and supporting installations.[220] The new atomic center was to be under the jurisdiction of the Bulgarian Academy of Sciences and would be built in three stages. First to be constructed would be the buildings for the reactor and cyclotron from the Soviet Union and for the Academy's Institute of Physics.[221] Work on this first stage of the center began in May 1956, and was scheduled for completion by the end of that year.[222] In a radio interview, in June 1956, Professor Emil Dzhakov of the Institute of Physics said that the atomic research center, when completed, would concentrate on the study of neutron physics and nuclear reactions, radio chemistry, the biological effects of radiation, and widespread practical applications of radioisotopes.[223] Somewhat earlier, Hungary and Bulgaria had announced plans to build a joint laboratory for the study of cosmic rays on Stalin Mountain in Bulgaria,[224] and construction of this laboratory also was begun in 1956.

However, delays in receipt of equipment from the Soviet Union, lack of funds, and other factors soon necessitated a drastic revision of these over-ambitious plans. As a result of talks held in Moscow in February 1957, the Soviet Union agreed thereafter to pay a "just and mutually advantageous price" for continued deliveries of Bulgarian uranium to the U.S.S.R., but the funds from such payments were to be used specifically for further development of Bulgaria's uranium mines. Bulgaria, in return, agreed to carry on most of her advanced research at the Joint Institute of Nuclear Research, in co-operation with other bloc nations.[225]

It will be a long time before the atomic research center in Bulgaria is completed. The "first stage" of the grandiose plan is still unfinished; even the research reactor from the Soviet Union apparently has not yet become operational, although it will probably go critical before the end of 1958. Nor are there any reports to indicate that the cosmic ray laboratory has been completed.

Bulgarian physics students began training in the Soviet Union early in 1956.[226] However, it was not until a year later that the Soviet Union agreed to make "substantial cuts" in the fees formerly charged Bulgaria for this service and for sending visiting Soviet technical experts to Bulgaria, and also to pay Bulgaria for reciprocal technical services to the Soviet Union.[227]

In spite of Bulgaria's serious shortage of conventional power sources,[228] the Soviet Union has not promised her atomic power reactors.

Since July 1957, a committee to co-ordinate all peaceful atomic activity has been functioning under the Bulgarian Council of Ministers.[229]

Bulgaria, like Rumania, is a member of the U.N.'s International Atomic Energy Agency, and she may eventually succeed in expanding her peaceful atomic program. For the more immediate future, however, she undoubtedly will have to abandon her high hopes for an advanced nuclear research center of her own and be content with limited training facilities at the college level.

Albania

Albania is the only European nation in the communist orbit which has not been offered Soviet aid toward a peaceful atomic program. She is not known to possess deposits of uranium or other materials that would be useful to the Soviet atomic interests. However, a Soviet-Albanian agreement on scientific co-operation, signed in December 1957, provides for assistance in "the study and exploitation of Albania's natural resources,"[230] and may thus augur a joint effort to locate uranium deposits. If uranium were discovered, a limited peaceful atomic program might follow.

Albania is primarily an agricultural nation with little industry, but both Soviet and Albanian leaders are making efforts to industrialize the country. From time to time, the question of Soviet peaceful atomic aid has been discussed between the two nations,[231] but it is unlikely that Albania can persuade the U.S.S.R. to supply such aid until industrialization has reached a more advanced stage. Power supply has long been a problem and will become more inadequate as industrialization progresses, so that eventually the Soviet Union may supply atomic power reactors.

A member of the International Atomic Energy Agency since August 1957, Albania could request help from that organization as soon as her industrial development reaches the point where conventional power sources will no longer suffice. Such a move would force the Soviet Union either to supply atomic power reactors or to permit the IAEA to enter into the atomic activities of the Soviet bloc. The former would doubtless prove the more attractive alternative, since it would permit greater Soviet control over atomic energy developments. Given the present rate of industrial development in Albania, however, the problem is unlikely to confront the Soviet Union before 1980.

It is also possible that, before Albania ever reaches a stage of industrialization that could force any Soviet action, the Soviets may decide to relinquish this poorest and most backward of the European satellites in return for Western concessions elsewhere in Europe.

For the next ten to twenty years, at any rate, Albania will probably have to be content with her present meager share of Russia's atomic plenty. A small number of Albanian physics students are being trained in the Soviet Union, and Albania participates to a limited extent in the Joint Institute of Nuclear Research, of which she is a member.

Other Bloc Nations

Neither North Korea nor North Vietnam is receiving Soviet atomic assistance, although both are members of the Joint Institute of Nuclear Research at Dubna and are taking a modest part in its work. At present, Soviet technical assistance to both nations is geared to furthering industrialization and improving agriculture and the existing small industry. In general, Soviet aid to North Korea has increased somewhat since 1956,[232] and a Soviet-North Korean Commission for Scientific-Technical Cooperation, similar to those previously established with more advanced orbit nations, has been set up.[233] A small number of Korean scientists are being trained in the Soviet Union.[234] With North Vietnam, scientific co-operation is confined principally to an exchange of technical books and publications.[235] Not being members of the United Nations, Korea and North Vietnam are ineligible for membership in IAEA. Both remain economically underdeveloped, and in the foreseeable future are unlikely to progress to a domestic program for peaceful uses of atomic energy.

* * *

So far, the U.S.S.R. has successfully retained control of peaceful atomic developments in the nations of its orbit. As young scientists in the more advanced satellite nations become more highly trained, as atomic power reactors are built there, and as new uranium mines begin operation, maintaining that control will become a more complex problem. The ultimate outcome will depend, in part, on three crucial factors: First, Moscow will have to continue exercising strict supervision of

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all uranium mining activities in orbit nations in order to guard against the possibility that ore may be diverted for use at home or for sale to the West. Second, efforts by satellite nations to build isotope processing plants will have to be curtailed. Third, the U.S.S.R. must prevent the satellites from constructing plants for the reclaiming of used reactor fuel rods. As long as these rods must be returned to the Soviet Union for reprocessing, such an arrangement precludes the possibility that plutonium, which could be diverted to weapons manufacture, will fall into the hands of the satellite nations.

The development of atomic power programs in Western Europe and increasing dissatisfaction with Moscow's atomic assistance are already prompting satellite scientists to try to design power reactors which will reduce the need for enriched uranium fuels. For example, Polish scientists are working on designs for power reactors that will transform U^{238} to plutonium for fueling subsequent power reactors.[236] Such reactors, if successfully constructed, would lessen the dependence of the Polish atomic power program on the Soviet isotope processing plants. Similarly, Czechoslovak scientists are working on improved designs for breeder power reactors,[237] which manufacture more fuel than they burn up. As the U.S. Atomic Energy Commission has pointed out, "breeders may eventually be very important to a large-scale atomic power economy."[238] More technical information on power reactor technology is becoming available all the time, and is disseminated by the scientific journals and through papers read at international meetings. Scientists in the more advanced satellite nations, who have access to these media, can thus bypass some of the technical problems of reactor design already solved elsewhere. In a few years, these scientists will also have the benefit of the experience gained in helping to build and operate their first atomic power stations, and the possibility cannot be discounted that they may ultimately work out power reactor designs which will decrease their dependence on the Soviet Union.

The goal of Euratom nations is to have a capacity of 15,000 megawatts of installed atomic power by 1967.[239] As atomic power networks in Western Europe become a reality, the more highly industrialized East European nations will be ever more anxious to alleviate their own power shortages by building similar networks.

On the other hand, political and economic instability in those nations, if it continues, will work to the advantage of the U.S.S.R. in its attempts to retain control of atomic energy activity in the bloc. The recent measures to tighten the economic and scientific interdependence of bloc countries also will help, but still more stringent control measures than those currently in effect will be needed to keep the developing atomic power programs in the various orbit nations closely tied to Moscow.

Proposals have been made to create a zone in Europe that would be free of nuclear weapons. The most important of these is the so-called "Rapacki Plan," proposed by Poland and endorsed by the U.S.S.R.,[240] which stipulates that no nuclear weapons shall be made or stored in certain European nations, including East and West Germany, Poland, and Czechoslovakia. The proposal, as it stands, would not curtail the expansion of programs for <u>peaceful</u> atomic uses in the orbit nations affected by the plan. Without prior guarantees of certain safeguards, including inspection, the West cannot agree to accept such an arrangement. One of the safeguards would have to be some means of preventing orbit nations from diverting plutonium from power reactors to weapons manufacture, and would thus actually help the U.S.S.R. solve one of the problems of maintaining control over satellite atomic programs.

There is little doubt that up to now the Soviet Union has refused to supply atomic weapons to its European satellites; the risks to the U.S.S.R. would be greater than the advantages would justify. In an official statement, Moscow has said specifically that no atomic weapons are being stored or produced on the territory of East Germany, Poland, or Czechoslovakia.[241] Prompted by a charge made by a Norwegian statesman, the Soviet statement was part of an intensive political campaign against Western plans to supply atomic weapons to NATO countries.[242] This campaign has grown in volume and intensity since the Soviet Union announced successful tests of ICBM's in 1957.

There have been several general Soviet statements hinting that, if West Germany received atomic weapons, the Warsaw Pact nations might also be atomically armed by Moscow. Strongest of these was Khrushchev's remark to W. R. Hearst on November 22, 1957: "Whether the armies of the countries signatories to the Warsaw treaty will be supplied with modern arms, including rockets with atomic and nuclear warheads, will depend on the situation, and on the lines to be followed by the countries belonging to the North Atlantic bloc."[243]

It would seem, however, that Khrushchev's statement and other, similar ones can for the moment be considered as political threats designed to support the general "atomic blackmail" campaign against the West. It is not entirely impossible that the Soviet Union will decide to re-establish some of the firm controls in orbit nations that in recent times have been somewhat relaxed, and will subsequently transfer tactical atomic weapons to Soviet troops stationed in those nations. Nevertheless, the risks that would accrue to the Soviet Union from so drastic an alteration of the status quo would be very great, and only a deep conviction that Western military forces in the NATO nations constituted a real threat to the U.S.S.R. could prompt such a shift in policy. As Soviet long-range missile technology continues to improve, the probability of such a change is bound to decrease.

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With the growing threat of a possible "fourth country" problem in the European satellites, Moscow probably will take new measures to assure its control of peaceful atomic developments in those nations. If a genuine political partnership develops between the U.S.S.R. and Communist China, the Soviet Union may come to feel that it would incur fewer risks from nuclear capability on the part of China than from a similar capability in the East European nations.

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IV. Soviet Sharing Outside the Bloc: 1956-1958

Moscow recognized the desire of nations outside the Soviet bloc to establish atomic energy programs, and was quick to exploit it for political purposes. Throughout 1955, there were vague general hints of Soviet willingness to offer other nations atomic assistance similar to that granted the "People's Democracies." After Malenkov had been removed from his post and the Khrushchev-Bulganin regime was firmly in power, a new phase in Soviet foreign policy began, in which "peaceful co-existence" was the prevailing line. In the first half of 1956, shortly after Bulganin and Khrushchev's good-will tour of Asia, representatives of countless foreign governments were invited to Moscow for bilateral talks on ways of improving their countries' relations with the U.S.S.R. But despite many hints of the possibilities of atomic aid, few tangible agreements for atomic assistance followed from these talks. Soon afterward, the Soviet Union was forced to cope with the economic setbacks consequent to the Hungarian revolt and to unrest in other satellite nations. These problems, and various other changes in domestic and international affairs, caused the Soviet leaders to revert to a more severe, less amicable posture in international relations. While they have continued

to make political capital of the Soviet peaceful atomic program, the few concrete offers of actual atomic assistance have been limited to carefully selected nations.

Bilateral talks between the Soviet Union and Yugoslavia began in 1955, and resulted in the signing of an agreement, at the end of January 1956, for peaceful atomic co-operation between the two countries. The U.S.S.R. would help Yugoslavia assemble a research reactor, supplying the necessary equipment and fuel. The reactor, similar to the one offered China, was to have a thermal capacity of 6.5 megawatts, with a possibility of expanding its capacity to 10 megawatts. It would be moderated by heavy water and fueled with slightly enriched uranium, and would produce isotopes. The nuclear fuel was to become the property of Yugoslavia, and the prices charged for the fuel and other material were to correspond to prevailing world market prices. Yugoslav experts were to take part in all phases of planning and constructing the reactor.[1] In addition, Yugoslav atomic specialists were to be trained in the Soviet Union, and technical documents were to be exchanged.[2] However, Yugoslavia was not entirely satisfied with Moscow's terms, and several series of further talks were held.[3] Toward the end of 1956, general Soviet-Yugoslav relations deteriorated once more, and it was not until a new

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rapprochement in 1957 that actual construction of the reactor was begun. In a paper prepared for the Second International Conference on Peaceful Uses of Atomic Energy, a Yugoslav scientist reported that it will be ready for use late in 1958.[4]

All the while, however, Yugoslavia has made clear its intention to seek further Soviet atomic help only when absolutely necessary. During the early talks of 1956, the possibility of Soviet assistance in building a cyclotron and, eventually, an atomic power station had been discussed.[5] However, Yugoslavia refused to accept the terms Moscow stipulated, and has since proceeded independently to construct a 16-Mev cyclotron and a zero energy research reactor.[6]

After intensive prospecting, uranium has been discovered, and plans to mine and process it in Yugoslavia are being developed.[7] Systematic studies of the comparative advantages of establishing atomic power stations or expanding the hydroelectric power network have been in progress since mid-1956.[8]

The chairman of the Yugoslav Atomic Energy Commission, Aleksandar Rankovic, has pointed out that Yugoslavia is to a considerable extent relying on her own resources in developing an advanced peaceful atomic program.[9] He has voiced Yugoslavia's dissatisfaction with the high cost and the restrictions

attached to atomic assistance from both the U.S.S.R. and the United States, and has indicated that Yugoslavia, with limited funds for atomic energy development, has found it more advantageous to arrange for atomic co-operation with some smaller nations.[10] Co-operative arrangements are in effect with Egypt, Poland, and France.[11] Yugoslavia also plans full co-operation with IAEA, of which she is a member. Unless more favorable terms are offered, future dealings between Yugoslavia and the U.S.S.R. in atomic matters will probably be limited to having a few advanced students sent to the U.S.S.R. for training and to exchanging documents and delegates to scientific conferences. The continuing ideological controversy between the two countries further reduces the likelihood of any extensive Soviet-Yugoslav co-operation in the atomic field in the immediate future.

More extensive Soviet atomic assistance was offered to Egypt, one of the prime targets of the Soviet "trade and aid" campaign since early 1955. Under the terms of an agreement signed in mid-February 1956, the U.S.S.R. was to help Egypt build an atomic research laboratory in Cairo and supply the necessary equipment, including a 3-Mev accelerator. Egyptian specialists were to be trained at Soviet institutes for work in peaceful uses of atomic energy. Jointly, the two countries

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would undertake prospecting for uranium and other atomic raw materials.[12] The agreement was soon extended to provide for Soviet help in equipping the new Egyptian atomic institute with a 2,000 kilowatt research reactor, similar to those offered the European satellite nations, and to be paid for out of credits available under an existing trade agreement.[13] Construction of the Egyptian atomic research center seems to be proceeding according to schedule. The research reactor went critical early in 1958,[14] and the entire installation, first of its kind in the Middle East, is to be completed in 1958. A considerable number of Egyptian specialists are in the Soviet Union for training in peaceful atomic applications.[15]

Egypt has announced that she will build her first atomic power station between 1962 and 1967.[16] Her trade with the Soviet Union is increasing steadily, and she is relying heavily on technical assistance from the U.S.S.R. in her over-all industrialization program. A new long-term loan and technical assistance agreement was negotiated with Moscow early in 1958, providing for further Soviet assistance in ore prospecting and development of mining.[17] Further agreements can be expected by which the U.S.S.R. will help Egypt build her first atomic power station in return for shipment of ores.

Moscow signed a general trade and credit agreement with Indonesia in September 1956, which provides for the training of Indonesian students in the use of isotopes and in other aspects of peaceful atomic applications at Soviet institutes.[18] Thus far, however, its implementation has been limited. Indonesia's co-operation with the Soviet Union in the atomic field probably will remain confined to student training and possibly the purchase of a few Soviet isotopes. The political and economic instability of the country is likely to prevent the development of any large-scale program for peaceful applications of atomic energy.

Vague offers of Soviet atomic assistance to other nations outside the orbit have not been followed by tangible agreements. Primarily, the U.S.S.R. has derived political advantage from holding out the possibility that it might offer such aid; it has sought thereby to support its long-range foreign policy goals in relations with the underdeveloped nations, and to supplement its atomic blackmail tactics vis-à-vis the West. The few non-bloc nations that are receiving tangible assistance were chosen on the basis of the same broader objectives, and similar criteria obviously determined the Soviet offers of peaceful atomic assistance that have been made through the International Atomic Energy Agency.

Even before the IAEA had come into being, the Soviet Union was using other organs of the United Nations to exploit the "have-not" nations' desire for atomic energy programs. In UNESCO and its economic subcommissions for Europe and Asia, in particular, Soviet delegates made vague offers of atomic assistance to member states. In April 1956, the U.S.S.R. proposed that the Economic Commission for Europe establish a special group to deal with problems of peaceful uses of atomic energy.[19] That same year, another proposal was to replace Euratom with an "all-European" organization for peaceful atomic co-operation, of which both the U.S.S.R. and the United States would be members.[20] In essence, both suggestions were ignored. Similarly, ever since the establishment of the IAEA, the Soviet Union has used its meetings to protest against the "strings" attached to U.S. atomic assistance and to strengthen the image of the Soviet Union as the world leader in peaceful uses of atomic energy.

Although the U.S.S.R. originally took little active interest in the forming of IAEA, it has since made grandiose claims about its part in the agency's establishment.[21] Much was made of the fact that the Soviet Union was the first of the major atomic powers to ratify the statutes of the new organization,[22] and this was presented as further proof of "the great importance

attached in the Soviet Union to the peaceful utilization of atomic energy, co-operation between peoples, and strengthening the peace."[23]

Soviet offers of fissionable materials and other assistance through the IAEA, however, have not come up to the American example. The United States has offered to make available to the agency 5,000 kilograms of U^{235}, and to match whatever contributions are made by other nations before July 1, 1960.[24] By contrast, the U.S.S.R. has offered only 50 kilograms of "highly concentrated" U^{235}.[25]

The United States, in addition, has offered to furnish between twenty and thirty expert atomic consultants without cost to the organization, to provide approximately 120 fellowships between 1958 and 1960 for training nuclear scientists in the United States, to contribute half the funds necessary to establish an IAEA fellowship fund of $250,000 for similar training in any other member state,[26] and to build an experimental reactor for one of the member nations.[27]

At the first general conference of IAEA in Vienna, in October 1957, the Soviet Union expressed its willingness to help specialists from member states learn various aspects of reactor technology -- including construction of research and power reactors -- and to train experts in isotope applications.

There were also some vague promises that the U.S.S.R. would help member nations in planning peaceful atomic programs and in prospecting for uranium.[28]

More tangible were Soviet offers to train students from IAEA member nations in atomic technology: some were to have their studies in the Soviet Union paid for by IAEA; others, from underdeveloped countries, would receive Soviet scholarships covering all their expenses. Several times since this offer was first extended, the Soviet Union has changed its mind about the number of such trainees it is willing to accept.[29] Present indications are that during the academic year 1958-59 forty to forty-five students will be admitted for a five-to-six-year intensive training program in basic fields of atomic technology, twenty-five of them on Soviet scholarships.[30] Furthermore, the U.S.S.R. has offered to accept fifty scientists from member nations -- twenty of them on scholarships -- for training programs lasting from three to six months.[31] Finally, the Soviets have matched the U.S. offer to furnish the services of twenty to thirty technical consultants to IAEA member states that request assistance in setting up peaceful atomic programs. The assignments are to be made by IAEA, and Soviet physicists and engineers will go on short-term consultative missions, all expenses for which will be absorbed by their own government.[32]

* * *

More than likely, the Soviet Union will continue to confine any large-scale peaceful atomic assistance outside the Soviet bloc to carefully selected nations, like Egypt, where such aid can best support Moscow's over-all tactics.

The likeliest candidates for bilateral assistance proposals are Japan and Burma. Soviet political maneuvers in favor of the prohibition of atomic weapons and cessation of nuclear tests have had considerable impact in Japan, first victim of atomic bombing. Even before October 1956, when the U.S.S.R. belatedly signed a peace treaty with Japan and resumed diplomatic relations, overtures to Japanese physicists were evident. A group visited the Soviet Union in 1955 and reportedly expressed enthusiasm about increasing their contacts with Soviet colleagues.[33] A research bilateral was signed with the United States in December 1955, but not without prior disputes and acrimony within the Japanese Science Council. Japan is currently prospecting for uranium, expanding its peaceful atomic program, and planning for atomic power stations to alleviate pressing shortages of power from conventional sources. So far, co-operation with the U.S.S.R. has been confined to a limited exchange of scientific delegations and technical publications.[34] As the Japanese program grows, however, Moscow is likely to make tangible proposals for negotiating an atomic assistance agreement.

Burma has been a principal target in Soviet efforts to win Southeast Asian nations to communism. During their visit there late in 1955, Bulganin and Khrushchev made several promises of technical assistance. A technological institute and a hospital were offered by the U.S.S.R. in 1956, and were under construction early in 1958.[35] New physics laboratories are being built at Rangoon University with the help of Lomonosov State University in the Soviet Union, which has also provided scientific textbooks.[36] Moscow is likely to offer Burma future assistance in the form of isotopes and student training, and would probably be willing to accept Burmese rice in payment.

Other underdeveloped nations likely to receive offers of some measure of atomic assistance from the Soviet Union are Afghanistan, Cambodia, Ceylon, and Pakistan. Ever since 1955, there has been a marked increase in Soviet credits to Afghanistan, the U.S.S.R.'s Asian neighbor to the south, and several installations, including a flour mill and a concrete plant, have been built with Soviet help.[37] As Afghanistan becomes more heavily industrialized, Moscow is likely to offer her isotopes as well as some training opportunities for atomic specialists in the Soviet Union.

Moscow's relations with Cambodia and Ceylon have improved since 1956, and both are receiving technical assistance from the U.S.S.R. and from Communist China.[38] It is reasonable to expect, therefore, that some offer of peaceful atomic assistance may be forthcoming.

Pakistan signed a research bilateral for atomic cooperation with the United States in 1955. To date, however, her atomic program does not measure up to that of her principal rival, India. In response to a direct question, Khrushchev once told a Pakistani newspaperman that it would be possible for Pakistan to obtain Soviet help in peaceful uses of atomic energy,[39] and it is quite possible that such help will be requested in the future, or that Moscow will make a more concrete offer. An initial trade agreement was signed with Pakistan in mid-1956.[40]

Among the more advanced nations, France and Brazil are only slightly less vulnerable to future offers of Soviet atomic assistance than Japan. France, with rich deposits of atomic raw materials, primarily in her overseas territories, is working to expand her atomic program as rapidly as possible. A plutonium extraction plant has been built, and France plans to use part of this plutonium to fuel fast breeder power reactors.[41] Since the spring of 1956, there have been sporadic

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discussions, initiated by the U.S.S.R., about the possibility of peaceful atomic co-operation.[42] If France is refused what she considers adequate assistance under her existing agreements with the West, she may try to negotiate an agreement with the U.S.S.R. to speed the development of her program.

Despite the fact that the U.S.S.R. as yet has no diplomatic relations with Brazil, Khrushchev has indicated Russia's willingness to co-operate with Brazil in peaceful uses of atomic energy either through IAEA or "directly on the basis of a bilateral agreement."[43] Discovery of Brazilian uranium and thorium deposits may prove an added incentive for a Soviet assistance offer. Brazil has negotiated both research and power bilaterals with the United States, but continues to be handicapped by an acute currency shortage. A Soviet offer of large, long-term credits on liberal terms might force the pro-Western government officials to establish diplomatic relations with the U.S.S.R., and might eventually lead to some degree of atomic co-operation with Moscow.

Whatever bilateral agreements with selected nations the Soviet Union chooses to conclude in the future, the present policy of making political capital of the sharing program is sure to continue. The propaganda potentials of Soviet "Atoms-for-Peace" exhibits have already been widely exploited throughout the world. The U.S.S.R. will continue to link its peaceful atomic sharing program to campaigns for prohibiting the use of atomic and hydrogen weapons, stopping nuclear tests, and outlawing nuclear weapons at overseas bases. Also, Moscow will capitalize on whatever disagreements arise over the terms of U.S. bilateral agreements, as was done, for example, in the case of a misunderstanding between the United States and Switzerland.[44]

The U.S.S.R. apparently embarked on the policy of peaceful atomic sharing with nations inside its orbit as a necessity that could no longer be avoided. Sharing outside the orbit, on the other hand, seems to be chiefly a useful supplementary device by which to attain certain established international objectives. If this observation is correct, it is safe to assume that the Soviet leaders will want the program to remain limited, lest it drain the resources needed for the expansion of peaceful atomic applications in the U.S.S.R. itself.

NOTES*

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Chapter IV

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THE SOVIET UNION AND THE ATOM: PEACEFUL SHARING, 1954-1958 by A. M. Jones; Research Memorandum RM-2290, November 20, 1958, Unclassified. 158 pp.
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