

Physics in **POLAND** and **RUSSIA**

Do the spectacular achievements of Soviet technology reflect the true state of progress in basic science behind the Iron Curtain? The author, a Brookhaven National Laboratory physicist, thinks they do not.

By *Donald J. Hughes*

THIS past summer I spent a very busy month in a manner I hardly would have predicted a few years ago—visiting Polish and Soviet scientists, accompanied by my wife, as a guest of their governments. The trip was unusual in that I was not attending a conference, as has been true for most visits of US physicists, but was lecturing and consulting on an individual basis. The resulting informality meant that I was able to learn about a wide variety of physics research and to talk at length to many individuals. As the Russian visit was preceded by two weeks in Poland, I had a chance to learn much about the Soviet work from within, so to speak. Actually, the freedom of discussion in Poland helped to prepare me, in a valuable way, for uncovering details of developments after I reached Russia.

The reader is perhaps curious as to how a trip of one month's duration behind the iron curtain is arranged, and may even be interested in making one on his own, hence a few words concerning the way in which our trip originated might be of interest. In January of this year I received letters from B. Buras, a Polish physicist I had met while he was visiting Brookhaven, and from L. A. Sliv, a Soviet physicist I had met at Copenhagen. Each letter asked if I would be able to accept an invitation to visit should one be sent by the Academy of Science. The AEC advised "say yes", which I immediately did. The invitation from the Polish Academy followed very quickly but several months then elapsed before permission was obtained from the AEC and the State Department to make the trip. The Soviet Academy, on the other hand, did not come through until June, its invitation actually arriving at Brookhaven when we were in Warsaw. US approval for the Soviet visit followed within one week, a notable accomplishment. Actually, our entry into the Soviet Union was delayed several days while we waited for the Academy to notify the Soviet embassy to issue our visas.

However, in spite of the delays on both sides of the curtain, the visits were accomplished. Even though two weeks in each country is a short time to gather information about physics and other aspects of life as well,

we certainly absorbed all we could, and I shall try to recount the most interesting and significant things that we saw, first physics, then some more general observations.

IN Poland almost all physics research is under the direction of the Academy of Science, which sponsors research in a large number of institutes. The present policy of the government, and a rather new one, is to support physics strongly. As a result there is a striking contrast between the work now beginning in the institutes and that of recent years in the universities, which is severely handicapped by poor facilities.

At one of the institutes, on the outskirts of Warsaw, a new research reactor is about to go into operation. In 1954 planning was going forward in Warsaw for the construction of a modest reactor, but in 1955 an advanced reactor was offered to the Poles by the USSR, an offer which was accepted. This reactor, built in the Soviet Union, is closely similar to four others that are being supplied by the Russians to satellite countries. It will operate at 2 megawatts, producing an average neutron flux of 10^{13} in the core, which consists of uranium rods enriched to 10 percent in U^{235} . The surface temperature of the uranium rods will be 90°C and the light-water coolant will reach about 40°C . The Poles are paying the Soviet Union 6.5×10^6 rubles for this reactor, roughly about one million dollars. I was told that the Soviets at first wanted 14×10^6 rubles but, after some negotiating, lowered the price. The reactor seems well engineered but has some rather cumbersome details, such as heavy gates in the beam holes that cannot be opened locally, but only by remote control from a distant control center.

Near Krakow a 12-Mev deuteron cyclotron with a 230-ton magnet (much overbuilt) is being installed. This cyclotron, which is costing the Poles 4.5×10^6 rubles, is obviously greatly overdesigned. It is situated in a very large building, built by the Poles, which will accommodate 250 scientists and all ancillary services.

It is interesting that, even though the Soviets have



Poland's Russian-built reactor at Swierk, just outside Warsaw. "The picture was taken while we were visiting the reactor with some Polish physicists and Russian engineers."

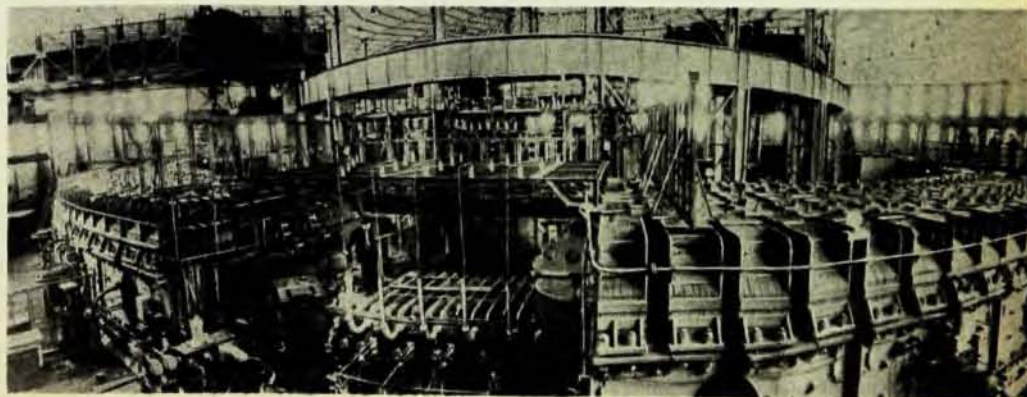
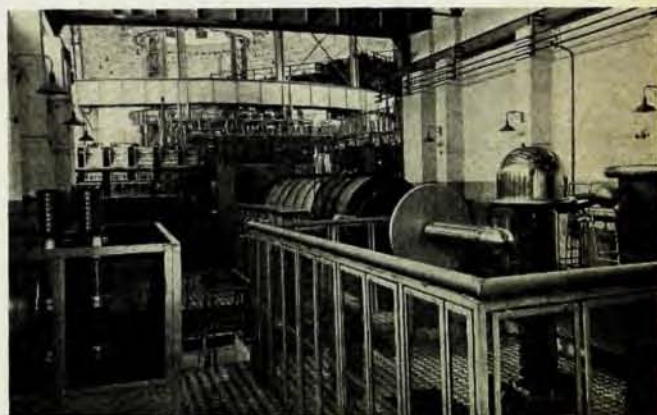
supplied the reactor and cyclotron for the Poles, they are doing very little in helping the Poles to use these machines. On their part, the Poles are extremely anxious to get help from the West and are not at all inclined to send their own scientists to Moscow for training. They obviously look to the West for leadership in pile neutron and cyclotron research and eagerly await any pieces of Western apparatus. One small example—they do not like the Russian photomultiplier tubes and would much prefer to get American or British models if they could.

There was much discussion in Warsaw of a "pulsed reactor" neutron source, reputedly being built by the Soviets at Dubno near Moscow. During the time I was in Warsaw, Blokhintsev, who is director of the Dubno Institute, gave a lecture in which he made strong claims for this source, apparently destined to put all neutron velocity selectors out of business. It was to have a pulse lasting $15 \mu\text{sec}$ and a neutron emission rate of 10^{17} per second during the burst. Neutrons would be timed over a flight path of 1 kilometer. The Poles asked me if I weren't worried about the competition, but implied that perhaps they didn't quite believe the claims. Nevertheless, I looked forward eagerly to learning about this potent neutron producer.

IN the Soviet Union physics research is even more carefully controlled from above than in Poland, by the all-powerful Soviet Academy. The work again is in

institutes devoted mainly to research with instruction being done at the large universities, such as the skyscraper University of Moscow. One of the principal institutes is the new Joint Institute of Nuclear Research, at Dubno, about 60 miles north of Moscow. It is here that the 10-Bev accelerator is located, which started nominal operation at 8 Bev last spring. I shall not spend time describing it for it has been covered in many reports already. It is interesting, however, that most Russians felt that its initial operation had mainly been for prestige and that it is not really an operating research instrument at present. Veksler, himself, who showed us the machine, said that it definitely is not ready for research and that it would take months of improvement before a sizeable current is obtained. He did feel, however, that in some four or five months 10^{10} protons per pulse would probably be attained. The appearance of the machine certainly bears out Veksler's remarks for we saw not a single research apparatus anywhere in its vicinity. The picture of course is much different at the 680-Mev synchrocyclotron, which so impressed the high-energy physicists who visited the Soviet Union. Here many pieces of equipment are jammed around the machine and as many as twelve experiments can be performed at the same time.

I talked at length with Blokhintsev, the director of the Dubno Institute, in order to find out if any neutron work was being planned there. He said that there was none, in spite of the fact that he had given a rather glowing account of the pulsed reactor when he himself was in Warsaw a few weeks earlier. When I questioned



General view of the 10-Bev proton accelerator at the Joint Nuclear Research Institute at Dubno, near Moscow. Top photograph shows the accelerator's injector. (Sovfoto)

Main hall of the 680-Mev synchro-cyclotron in the Nuclear Problems Laboratory of the Joint Nuclear Research Institute. Many pieces of equipment are jammed around the accelerator and as many as twelve experiments can be conducted simultaneously.

(Sovfoto)



him directly about it, he said that this was an idea they had worked on but that it did not seem at all promising and probably nothing would be done with it! Most of the low-energy neutron research, or "neutron spectroscopy", is done at the Institute for Thermal Research, which is under the direction of A. J. Alikanov. Here the D_2O -moderated reactor is almost reconstructed and will start to operate in a few weeks, at 2 megawatts power with a flux of about 10^{13} . Vladimirsky is working on a new fast chopper to use with the reactor, 30 cm in diameter and designed to run at a speed of 30 000 rpm, using a magnetic support.

I tried very hard while at Alikanov's laboratory to get any possible information about research reactors of high flux. However, after repeated questions I concluded that there are no plans for research reactors in the range of 10^{14} flux, of which several types are now being built in the United States. There was some discussion of the pulsed reactor but the opinion of the scientists was that it was not a very promising idea and probably would not be built. They said that there had been some talk of a high-flux reactor for Dubno but that it would require a long time and plans had been abandoned for its construction. I shall return later to the possible reasons for this surprising lack of effort in neutron physics. At the same Institute the 6-Bev strong-focusing synchrotron is being built under the direction of Vladimirsky. The building for this instrument is practically complete and the machine should be running in 1960, according to the present schedule.

At the Physical Institute, directed by Skobeltzyn, the physicists were quite proud of their 280-Mev synchrotron which produces 15 000 r/min at 1 meter. The neutron spectrometer idea using the slowing-down time in

lead, reported at Geneva in 1955, is being pushed very hard even though it has a resolution of only 30 percent. It is hoped that this will be a very good instrument in the region of 10 to 20 kilovolts where conventional neutron velocity selectors have their poorest resolving power. Here, as in every laboratory I visited, the physicists were very anxious to learn about our plans for neutron apparatus and what we intended to do with it.

AND NOW, leaving the factual aspects of physics research, I shall recall some of the more subjective things, the general implications and the relationship to our own scientific progress in the United States. In Poland one is immediately impressed with the great poverty, with the widespread war damage that is yet to be repaired. In the center of Warsaw, the ghetto, leveled to the ground by the Germans, is still practically in that condition. Physics at the universities is in an extremely poor position, although the progress that has been made excites one's admiration, considering the extreme difficulties that had to be overcome in the process. To re-establish research after the war almost every piece of equipment had to be built by hand and it was only because of great determination that physics now exists at the universities. The excellent facilities now being built at the institutes in Warsaw and Krakow stand in great contrast, but these are very new developments and result from the conscious effort on the part of the present government to push science.

The scientists themselves are definitely in a low economic status and such things as spacious living quarters and automobiles are out of the question for most of them. Actually, in Warsaw there are few automobiles; instead there are a great number of open-bodied trucks,

At right: V. Petukhov, deputy director of the High-Energy Physics Laboratory at the Institute in Dubno, V. Veksler, corresponding member of the USSR Academy of Sciences and director of the laboratory, and L. Zinoviev, chief of the Starting Group, watch a beam of accelerated particles with the help of an oscilloscope.

Below: V. P. Jelepov, director of the Nuclear Problems Laboratory, Wang Kag-Chang of the People's Republic of China, and M. S. Kozodayev, assistant director of the laboratory.
(Sovfoto)



with planks for seats, being used as buses. There are also very many horse-drawn carts throughout the city. Prices of food are high, of clothing exorbitant, and of vodka low.

Yet in spite of the difficulties the scientists are outspoken, cheerful, friendly to the West, and optimistic for the future. They were very open about their high opinion of Western science, both in the leadership of fundamental research and the superiority of most items of research equipment. Even though the Soviets had furnished them with a really first-class research reactor they were not in the least interested in going to Moscow to learn to use it. For example, they had asked me to come to help them in their program with the reactor, and they were extremely anxious to get American physicists to spend a year or two helping them with their research.

Anti-Russian feelings are expressed rather widely by the population as a whole, from the man-on-the-street to the intelligentsia. These feelings are revealed well by the anti-Russian stories that are told quite freely by the people. Some concern the "Palace of Culture" which stands next to the ghetto—an ornate white tower, gift of the Soviet Union, that is occupied by the Polish Academy of Science. Most scientists mentioned that they visited the palace as infrequently as they possibly could, and remark that its top is the best place from

which to view the city of Warsaw—because in that case one cannot see the palace. Its architectural style is referred to as "gangster wedding cake". The Poles also describe the two newspapers that are read in the Soviet Union, Pravda (literally "the truth") and *Isvestia* (literally "the news") by saying that Pravda is not *Isvestia* (news), and *Isvestia* is not Pravda (true).

The people speak with great pride of the rapidly lessening Russian influence in Poland. For example, we were told that a year ago there were Russian officers stationed in every small village in Poland but that all of these officers have now left. It is true that the Soviets exert great economic influence on Poland. Thus the rich oil fields that were Polish before the war are part of Russia, and Poland is now dependent on Russia for oil.

In general, the people seem to have a rather good opinion of their present government, or rather of Gomulka, who they think is managing well the difficult problem of maintaining some independence for Poland and getting along with the Soviet Union as well. They do not seem unduly fearful of their own government and even criticize it relatively freely. In this connection we heard the remark that Poland, having adopted socialism, will in two years have a living standard equal to that of Switzerland—that is, if Switzerland also adopts socialism.

In some ways my previously held impressions of Soviet science and scientists were changed by my visit to Russia, particularly with regard to the standard of living of Soviet scientists and the relative position of their work and ours. The first matter is easily handled but the second is much more subtle and requires careful examination. Regarding the general position of Soviet scientists with regard to salaries and social position we were much surprised to find that they were not doing nearly as well as Western scientists of the same rank. We had many opportunities to talk about the way in which they lived and to compare actual salary figures. Thus the starting salaries of top PhD's in Russia are about 3000 rubles a month, which corresponds to about \$300 per month, say half of the United States level. I



Homes of Russian scientists. The Joint Nuclear Research Institute's housing estate in Dubno. (Sovfoto)

am here converting at the so-called tourist rate of 10 rubles to the dollar, which in our experience is about the actual value of the ruble in terms of purchasing power.

It is true that relative to skilled workers the Soviet scientists are well treated, but this simply means that the skilled workers are much poorer relative to our skilled workers than are their scientists. At levels above beginning PhD's the salaries seem to remain at about half those in the US in terms of real purchasing power. This information may come as a surprise when compared with the stories that have been current about Soviet scientists having cars, chauffeurs, and homes in the country. These stories certainly do not apply to the scientists with whom I talked, men usually at the level of PhD's plus 5 to 20 years of experience. The only way in which these stories do apply is to the very few men who are members of the Academy. Membership in the Academy is quite limited, however, actually only the directors of the laboratories that I visited were Academicians. Alikanov for instance, who directs the Nuclear Physics Laboratory, does have a home on the grounds supplied by the Academy plus one in the country. But it is only these very few people who obtain special treatment and all the other scientists do about half as well in their real standard of living as our scientists. For example, very few of the men we met owned cars of their own, and they all lived in rather small flats.

The other respect in which my own opinions were changed somewhat, and in which I reached a conclusion different from those usually expressed by the US physicists who attended the high-energy conference, is with regard to the Soviet position in physics relative to our own. Here my feeling is that the Soviets certainly do not lead in basic research and in fact in most of its branches lag behind us. They do excel in certain fields, largely development of large equipment, where they have decided to devote intense effort. This conclusion seems important to me in analyzing any of the recent developments that are referred to as evidence that the Soviets are passing us or have already done so. Such things as the Soviet atomic power plant, the 10-Bev accelerator, and the earth satellite are very good examples of this type of evidence. In each of these cases the Soviet high command has picked the particular development and has pushed it ahead without regard for

cost or manpower. These developments, however, are not basic science and are the type of things that can be pushed to rapid success if funds are not limited.

The procedure of picking certain fields for rapid development is of course intimately related to the way in which all science is organized in the Soviet Union, and the key to the situation lies in the fact that the Academy has such absolute control over scientific activities. This strong control by the Academy is shown in many ways, for example in the case of our visit by the handling of the request to invite me, which was made by Professor Sliv of the University of Leningrad. This request was made to the Academy in February of this year yet the invitation was not sent to me from the Academy until June. When I did arrive in Moscow a few weeks later, Professor Sliv had not been informed that I was to visit and just by chance learned of my presence as he was leaving for his vacation. All invitations to meetings are handled through the Academy in this way and the individual scientists have no way of knowing what will happen within the Academy. A parenthetical remark that is important to make here is that because of the all-encompassing nature of the Academy's activities Western scientists must be extremely patient when making arrangements with their Soviet colleagues. Even though the Soviet scientists individually want to cooperate very much, the necessity of all arrangements being made through the Academy means that often long, and to the Western scientist unexplainable, delays occur. We must develop extreme patience because these inexplicable delays are not the fault of the individual Soviet scientists.

The strong control of the Academy extends not only to the type of research to be done but even as far as the opinions expressed by scientists. We noticed for example the day we arrived in Russia that there were two letters to the editor in an English-language Soviet newspaper. These letters, supposedly voluntarily submitted, were by Skobeltzyn, Director of the Nuclear Institute and Mescheryakov, head of one large phase of research at the Dubno laboratory. The letters were in typical propaganda style, blaming the West for war-like activities such as the development of atomic bombs, whereas the Russian activities were all peaceful. The letters expressed extreme hate for the West yet the day after reading these letters in the paper we were talking to

Mescheryakov, who explained his experiments as a typical scientist, extremely friendly and vitally interested in our experiments as well as his own. The impression we gained from this and other experiences was that the scientists learned to separate their scientific work, which may be of high caliber, from propagandist political activities sponsored by the government.

Of course the close control extends beyond science and this control is obvious in many phases of life. For example, we were in Leningrad when a "demonstration" occurred, in which hundreds of thousands of people, organized according to their place of employment, march through the streets to converge on a large square in the center of the city, where they are reviewed by the government. Although these demonstrations are always described officially as spontaneous, we watched from our hotel window while one column of the demonstrators, about a dozen abreast, marched past for at least three hours, the stream of people being directed and held in order by hundreds of soldiers.

The control of students is extremely close, as we learned by talking to some university students, not Russian, who had spent several years at Moscow University. We learned from them of the severe control exerted on the students and the way in which any chance of free discussion is stifled by close watching and reports to the police. It is easy to see that students learn under these circumstances that to get along it is best for them not to express any critical opinions, and they probably tend not to think too much outside their own field.

The efficacy of this intense propaganda relative to the uneducated masses is often granted but a reservation made in the case of educated people. However, we were fortunate to see the propaganda system in operation at a crucial time for we were in Moscow on July 3 when the government purge occurred. On July 3 the scientists we were with would not express any opinions as to what was taking place; however, the next day after they had had a chance to read Pravda, things were different. Then several people, including scientists, willingly gave us all the same explanation of why the bad men, such as Molotov and Malenkov, had been put out of the government, which itself was always good. Our impression was that the people who were giving us these opinions actually believed them in an unquestioning way.

IT is my conclusion that the intensely strong control exerted in sciences and all other aspects of life has the effect of accelerating some phases of science, and at the same time, of hindering others. With the dictatorial control that is expressed by the Academy it is obviously true that certain fields can be picked to be pushed with all effort. It is difficult to say just why certain things are selected for the push, but it seems that spectacular items often are, and when success is achieved, as with the recent satellites, the propaganda value is utilized to the utmost. This kind of pressure on selected topics does not work well at all, on the other hand, in basic research and it is here that the Soviets lag behind us.

A great impression was made on Western scientists



Part of one column of a "spontaneous demonstration" in Leningrad as seen from a hotel window.

in the high-energy field but when one analyzes the situation it is again development work, here the building of the 10-Bev accelerator, that impressed so much. The actual discoveries in basic science are not impressive, however, even in the high-energy field where the Russians have pushed so very hard. In other fields of basic science the activity is almost zero; for instance there is no work at all in the Soviet Union in the field of neutron diffraction, one that has developed greatly in the rest of the world. In my own field, neutron physics, I could find no activity to compare with that in the United States where, for example, many high-flux research reactors are being built or planned. My own conclusion can only be that this happens to be a field in which they are not applying great efforts, directed from above by the Academy. There are also many other kinds of research in which the Soviets are not doing very much. It is hard to see how basic science can advance in a situation in which a few fields, usually those that will produce results of propaganda value, are the only ones that are pushed.

Along with this system there is of course a great reluctance on the part of the individuals to criticize the work of others or even to be interested in what is going on outside of their own laboratory. When I compare the free give and take of scientific information in the West with this strictly regimented system in the East, I cannot help but conclude there is little danger that the Soviets will pass us up in basic research.

For people who cannot distinguish between basic and development work, there is always the tendency, when the Russians make a spectacular success in the development line, to suggest that we put more effort in these same applied fields in which the Soviets achieve success. Unfortunately, this procedure would be an imitation of their methods and would do a great deal to hurt our own basic research, the source of future development. There is some evidence of a change in the Soviet Union at present, that the leaders realize that their own system does not advance basic research and that they are making efforts to overcome the disadvantages and bolster basic activities. But my own opinion is that the difficulties go so deeply into the fundamental structure of the Soviet society that it would be impossible to gain the freedom of research so necessary to progress without a change in the Soviet government more deep-seated than we can anticipate for decades.