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Poland

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NATIONAL INTELLIGENCE SURVEY

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This chapter was prepared for the NIS by the Central Intelligence Agency. Research was substantially completed by April 1973.

Poland

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This chapter supersedes the scientific coverage in the General Survey dated September 1970.

FIGURES

Science

A. General (S)

Poland is a leader in science among the Communist countries of Eastern Europe but trails far behind the U.S.S.R. in scientific and technological achievements. Poland has a strong scientific tradition and in its long history has produced some outstanding scientists. A significant development of scientific achievements took place during the Renaissance, with the establishment of the Academy at Krakow[1] in the 14th century; it later became the Jagiellonian University. One of its greatest scholars was Nicolaus Copernicus, famous for the creation of the heliocentric theory of the solar system. During the 1880's, successes were achieved by such individuals as Z. F. Wroblewski and K. Olszewski, who obtained liquid oxygen and nitrogen in large quantities for the first time. The work of Madame Sklodowska-Curie, the Polish-born Grench chemist, is known throughout the world of science. Both the Communist Party and government leaders have believed that science and technology are of great significance to the country's development and have, therefore, provided substantial financial support for research and development in relation to Poland's size and national income.

In recent years a general opinion has emerged that Poland cannot compete broadly in all areas of science and technology and that the future of Polish science must lie in concentration of the country's research and development capabilities in selected priority areas that are related to overall economic needs. There has been considerable difficulty, however, in obtaining agreement on which areas should be stressed. The government is forcing the issue by providing increased funds for applied research in certain areas at the expense of fields designated to be of lesser importance. Changes are taking place slowly, since there is much resistance to the government's efforts to move scientific specialists from the universities and institutes of the Polish Academy of Sciences (PAN) to research laboratories under the industrial ministries. There is a large gap between the work of the basic scientists and the relatively simple needs of Polish industry. Applied research is increasing, but Poland will depend heavily on licensing of foreign technology to stimulate the development of technologically oriented industries.

Progress in science is favored by government support of research, the high level of literacy, and a strong system of free education. The higher educational system emphasizes the training of scientists, engineers, and technologists. Polish scientists, although by no means free from politics, have been less burdened by political dogma than scientists in the U.S.S.R. and Czechoslovakia. There are, however, several factors which have hindered scientific progress, and one of these is the atmosphere of uncertainty, disorganization, and apprehension among working-level scientists brought about partially because institute directors are too occupied with politics to pursue research. The politically motivated purges that followed the crisis in the Communist Party in 1968 greatly affected universities and scientific research institutes. Approximately 5,000 students, professors, and research workers were either arrested or dismissed from their positions or association with the universities. Of the entire group, 150 were professors, 50 of whom were members of PAN. Morale of the scientific sector has been greatly affected, relations between Polish researchers and their counterparts in other Communist countries are strained, and communications within the scientific community are restricted. It does not appear that politics is more important than scientific ability in obtaining a position of leadership, especially in the physical sciences. When two individuals appear to be about equal in scientific ability, however, the person with party membership is always favored.

Facilities for research have suffered from inadequate equipment, caused in part by a shortage of funds for foreign purchases. As a result, large amounts of time are spent by scientific workers in the construction of special equipment and instruments. Research workers are handicapped by the long delays (1 to 2 years) in securing supplies and chemicals which are not produced in Poland. There is a lack of coordination between Polish research as practiced by

[1]For diacritics on place names, see the list of names at the end of the chapter.

research scientists in governmental institutes and in higher educational institutions and Polish industry. Industry managers receive bonuses for the number of units produced and are not interested in taking risks with new products or processes. Following World War II, the Polish scientific establishment was almost completely destroyed and had to be rebuilt.

Both chemistry and physics are active fields of research. Nuclear research is important but has been deemphasized in recent years. Medical sciences receive good support. Astronomy, which has in the past been an important area of scientific activity, has been assigned a relatively low priority by the present government. Mathematics, which has been one of Poland's strongest fields of research, has been hampered because of its low priority. The Poles have excelled in mathematical research fields that cover modern analysis, topology, logic, and applied mathematics.

The Polish Government recognizes the need for scientific cooperation with foreign countries and has entered into cultural-scientific agreements with both Communist and Western countries. Normally, close ties are maintained with other Communist countries, especially the U.S.S.R. and Czechoslovakia, through their respective academies of sciences, but in reality there is little scientific collaboration among the Eastern European Communist countries, due apparently to mutual mistrust and bureaucratic red tape. Much of the Polish scientific and technical program is coordinated through the Council for Economic Mutual Assistance (CEMA) to avoid duplication of effort. The Polish-Soviet Commission for Scientific-Technological Cooperation was set up to encourage exchange of scientists and scientific information, but experience has indicated that the Poles can count on very little help from the Soviet Union. The Soviets appear to have little respect for the work of Polish scientists. Polish nuclear research scientists work with Soviet scientists at the Joint Institute for Nuclear Research, at Dubna, U.S.S.R., but the Soviets do not allow the Polish scientists to work on high-priority projects. In fact, the U.S.S.R. has been reluctant to provide technical information which would make Poland more competitive with the Soviet Union. As a result of the lack of wholehearted cooperation, many young Polish scientists refuse to go to the U.S.S.R. for study or research.

Scientific relations between Poland and the United States have improved substantially during the last few years. Prof. Jan Kaczmarek, the Minister of Science, Higher Education, and Technology, has stated that he favors scientific ties with all countries, including the United States, but the president of the Prestigious Polish Academy of Sciences, Prof. W. Trzebiatowski, has noted that the Soviets are displeased when Polish relations, even in scientific fields, are too close with the United States. Polish coordinating units for Polish-American scientific cooperation were established in the late 1950's and early 1960's to plan and administer research grants financed through the use of U.S. PL-480 funds. A number of cooperative scientific and technical programs are underway between the two countries. In 1972 there were more than 50 active collaborative programs in the health and agricultural fields alone. Many prominent Polish scientists have studied in the United States under exchange programs. Government officials, however, are wary of this practice, because the higher standard of living in the United States induces many scientists to stay. Generally, visits by Polish scientists to other countries are limited to 3 months.

Military research and development programs are conducted under the auspices of the Ministry of National Defense. Autonomous control of all scientific and technological activities is maintained by the Ministry of Internal Affairs.

Many foreign scientists visit Poland each year to take part in symposia, meetings, and other activities organized by PAN. It was estimated that in 1971, about 3,000 scientists from all over the world participated in about 340 such events. Polish scientists also attend meetings held abroad. Poland is a member of many international scientific organizations, including the International Atomic Energy Agency (IAEA), the International Union of Geodesy and Geophysics (IUGG), the Intergovernmental Oceanographic Commission (IOC), the Conference of Baltic Oceanographers, and the Conference on Coastal Engineering. Other international groups whose activities involve participation by Polish scientists include the International Union of Theoretical and Applied Mechanics (IUTAM), the International Scientific Radio Union, the International Society for Scientific Education, the International Academy of Astronautics, the International Academic Union, and the International Laboratory of Strong Magnetic Fields and Low Temperatures.

B. Organization, planning, and financing of research (S)

Scientific and technical activities in Poland are organized and completely controlled by the Communist Party and the government. Research and development are conducted by the institutes of the

Polish Academy of Sciences (PAN), by the universities and technical universities under the Ministry of Science, Higher Education and Technology, and by laboratories and institutes under the jurisdiction of other government ministries, including the Ministry of Health and Social Welfare, the Ministry of Agriculture, the Ministry of National Defense, and the industrial ministries (Figure 1).

A Committee for Science and Technology (KNiT) was established in 1963 to set up priorities in research and development, undertake general planning and coordination of scientific and technological activities, and advise the government on funding of research activities. The KNiT also supervised the application of major scientific discoveries and inventions, and encouraged the effective use of foreign scientific and technological achievements. For many years there was a struggle for power over scientific affairs between the PAN and the KNiT and, in an attempt to reconcile the differences that had developed, the government appointed Prof. Jan Kaczmarek, then Chairman of KNiT, concurrently as Scientific Secretary of PAN. Since he is also a member of the Central Committee of the Party and a member of the Presidium of the Council of State, he holds a strong position in Polish science and technology. In March 1972 a reorganization of the education ministries resulted in a restructured Ministry of Education and Training, and the creation of a new Ministry of Science, Higher Education, and Technology headed by Prof. Kaczmarek. In the process the KNiT was abolished. Responsibilities of the new ministry are to develop national policies and priorities for scientific and technological activities; to coordinate research and development at all centers; to stimulate scientific liaison with other countries; and to develop and implement national plans for the training of research personnel.

Created in 1952, the PAN, although less powerful than formerly in scientific affairs, is still the foremost scientific organization in Poland. Structurally, it resembles the Soviet Academy of Sciences. It is the major instrument for conducting basic research and is also responsible for some applied research; the latter is done in PAN's institutes. At the request of the government or state administrative bodies, the PAN organizes inquiries demanding expert scientific opinions in connection with the development of

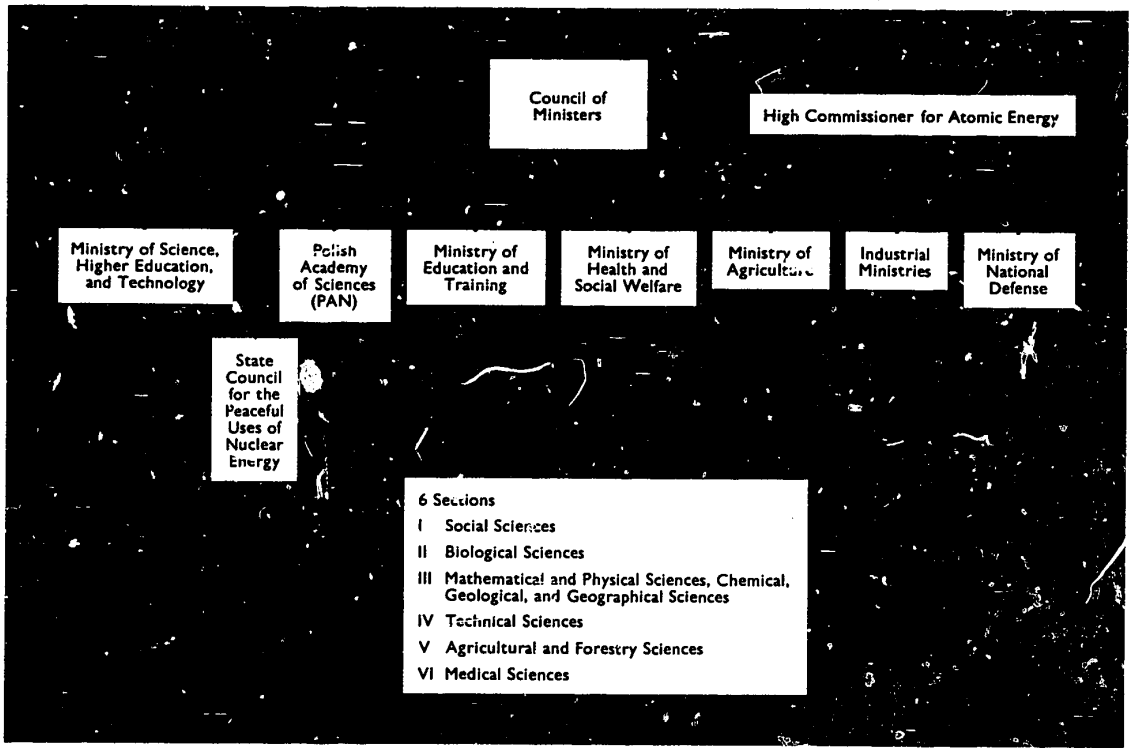

FIGURE 1. Organization for scientific and technical activities in Poland, 1972 (C)

particular fields of economics, technology, and science. PAN cooperates with the state administrative bodies that supervise higher education in the planning and establishment of the curriculums and in arranging postgraduate courses. The PAN, with headquarters in Warsaw, subsidizes research by scientific workers throughout the country and submits proposals to the government which relate to organization of research, the equipment of scientific centers, and the financing of research in its own facilities and in the universities. It trains scientific workers in its own scientific research establishments, confers doctorate degrees, and grants scholarships in accordance with the requirements of the Ministry of Education and Training and the Ministry of Finance. In Poland and abroad, it organizes scientific meetings and participates actively in scientific conferences.

PAN is organized into six sections: Social Sciences; Biological Sciences; Mathematical, Physical, Chemical, Geological and Geographical Sciences; Technical Sciences; Agricultural and Forestry Sciences; and Medical Sciences. Sixty-three scientific societies, including the Polish Chemical Society, the Polish Physical Society, the Polish Mathematical Society, and the Polish Astronomical Society, are affiliated with the PAN. It supervises approximately 60 research units including 24 institutes and 33 establishments and laboratories, employing about 6,500 persons. While a majority of these research facilities are located in Warsaw, some are located in other urban areas. Many of the PAN institutes, especially the technical ones, cooperate with industry and conduct research for the Ministry of National Defense. Directors of PAN institutes have considerable power, and often an outstanding director will assemble a staff of talented young scientists, thus creating a superior institute. In order to strengthen applied research, plans have been advanced to transfer some of the staff from the Academy's institutes to the higher educational institutions and ministerial research institutes throughout the country. Also, some PAN applied research institutes are being placed under the jurisdiction of industrial ministries, as in the case of the Institute of Electronics Technology, Warsaw, which was transferred in late 1970.

The various government ministries operate about 100 research and development laboratories. These laboratories conduct research aimed at targets set by the ministry concerned; most of the research is applied, although some related fundamental research is undertaken. The research done throughout the country in university departments, laboratories, and other research centers of higher education is of great importance to the progress of Polish science. Much of the research conducted in the higher educational institutions is basic in nature, but the universities and technical universities are also undertaking applied research to promote the national economy. The Ministry of Health and Social Welfare is responsible for the administration of a number of research institutes and 10 medical academies. This ministry has a Scientific Council which is comprised of outstanding representatives of the various scientific branches of medicine who act as an advisory and consultative group to the minister. The Ministry of Agriculture operates a number of agricultural research institutes and experiment stations and cooperates with other scientific institutions in the field of agricultural science. All agricultural research is coordinated by the Interministerial Commission for the Coordination of Scientific Research in Agriculture and Forestry, which includes representatives of several ministries and operates through Section V (Agricultural and Forestry Sciences) of the PAN. With the demise of KNiT, the Ministry of Science, Higher Education, and Technology is now involved, and the national scientific interest is represented by the ministry.

Military research and development are directed by the Ministry of National Defense. Reportedly the Main Council of Military Higher Schools, an advisory body within the Ministry of National Defense, coordinates military research and development for the armed forces. Specific responsibility for actual research rests with *Zarzad-IX* (Directorate IX), Techniques and Military Technology, of the Polish General Staff.

The nuclear energy program is directed by the State Council for the Peaceful Uses of Nuclear Energy, which has ministerial status. It is chaired by the Government High Commissioner for Atomic Energy and is composed of representatives of the Committee for the Peaceful Uses of Nuclear Energy of PAN, various ministries and institutes, and leading scientists. A reorganization of this body has been anticipated for some time.

The Council of Ministers directs the overall science policy. Research and development are carried out on the basis of central plans for the advancement of science and technology, which are part of the National Economic Plan, based on 5-year and 2-year periods. The science and technology development plans (both 5-year and 2-year plans) include a list of high-priority projects directed toward new technology; a list of important basic research topics in natural, mathematical, and social sciences; and the principal approaches for development of technology in various sectors of the national economy. In 1971 the KNiT,

which had been responsible for items involving technology, directed almost all of the priority areas in the National Economic Plan involving applied research and product development. The plans for basic research are worked out by the PAN. It is assumed that the new Ministry of Science, Higher Education, and Technology will take increasing responsibility for the planning of science and technology development. The various plans stress the need for professional scientists and assistants in all disciplines, and, therefore, provisions are included for developing an effective system of training technical, laboratory, and other auxiliary staffs for the research establishments. The plans are very specific in that the government supports particular research projects, rather than financing the operation of centers.

Scientific research and development activities are financed through funds from the state budget, special funds, and current expenditures of enterprises. The state budget provides directly about 40% of the total expenditure for research and development. It provides funds for the current expenditures of the institutes under the PAN and for the expenditures of research and development organizations under those ministries which do not accumulate special funds; much of the research conducted by higher educational institutions; certain special tasks initiated by the former by autonomous KNiT; and capital expenditures of all research and development organizations. The special funds include the New Production Starting Fund and the Technical and Economic Progress Fund; the latter is based on an average levy of 0.4% of the value of industrial products. This fund is used to finance research and development projects which carry a high priority with respect to the national economy. Some research and development is financed from current proceeds of the government-owned industrial enterprises.

In some cases the institutes of the PAN receive funds from the various government ministries; for example, the Institute for Fundamental Technical Problems (IPPT) has contracts with various industrial ministries under which it does work on industrial applications of scientific techniques and assists in the training of technicians. Some Polish scientists concerned with medical and public health research receive funds from the United States under PL-480.

According to information put out by the PAN and the former KNiT, Polish expenditures for research and development have been increasing at an annual rate of over 12% during recent years. As indicated below, the percentage of gross national product expended for research has also increased:

1961	*1.1*
1968	*1.5*
1969	*1.7*
1971	*2.1*
1975 (projected)	*2.5*

The 1968 expenditure for research and development was about 10 billion zlotys. National policy calls for this expenditure to increase to about 25 billion zlotys by 1975, of which 8.3 billion zlotys is to be financed by the state budget, 10.5 billion by the Technical and Economic Progress Fund, and 6.2 billion by the current proceeds of enterprises. The PAN budget was only about 850 million zlotys in 1968. The Poles recognize that one of their major problems is in equipment investment. At the present time, the value of technical equipment per research worker directly involved in science programs is relatively small and attempts are being made to bring it in line with more advanced countries of Europe.

C. Scientific education, manpower, and facilities (S)

The quality of scientific education in higher educational institutions is good. Scientific and technical training is available at 48 higher schools, and at the PAN institutes which provide training at the graduate level. With the exception of 10 medical schools under the Ministry of Health and 4 military higher schools under the Ministry of National Defense, the country's universities and technical universities responsible for scientific and technical education at the college level are under the new Ministry of Science, Higher Education, and Technology. The ministry makes decisions on organization of research work at its universities and colleges and on their cooperation with other scientific research bodies. Some vocational schools are maintained by certain industrial ministries. The most important military research and development center is the General Jaroslawa Dabrowski Military Technical Academy (WAT) in Warsaw; it trains military engineers and awards both graduate and undergraduate degrees.

Polish universities have undergone extensive reorganizations since the student disturbances of early 1968; during 1969 many administrators were discharged and replaced by party members. Many of the new administrators are not scientifically competent, and the morale of scientists has declined. With the government's emphasis on industrialization,

higher educational institutions have been pressured into expanding their technical educational facilities. Polytechnical universities are being strengthened and new engineering faculties are being added to schools. Some of the technical faculties in universities have been transferred to higher technical schools, leaving only faculties concerned with science and the humanities. The shortage of qualified teachers at all levels is a serious problem. The ratio of enrolled students to faculty members at polytechnical universities and specialized engineering schools is much lower than the ratios at various state universities. High school science teaching is very poor. The government has tried without much success to increase the number of science teachers by establishing scholarship funds.

Postgraduate scientific education is available at many of the universities, technical universities, and institutes of the FAN; masters and doctoral degrees are offered. Doctoral degrees in the scientific field are awarded to persons who have completed studies at a higher educational institution, achieved the title of master, master of engineering, physician or equivalent, and shown ability for scientific research work; succeeded in passing the prescribed doctoral examinations; and submitted a doctoral thesis. The titles of extraordinary professor and ordinary professor in the field of science are awarded by the Council of State to persons who, having previously received a doctoral degree in science, have made substantial contributions in scientific research or education. At the end of 1967, about 45,000 persons with a higher education as scientists and engineers were employed by research and development institutions in Poland. Of these 5,300 held doctoral degrees, 904 had the title of professor, and 3,678 held senior scientist positions. In 1967, 302 doctors' degrees were awarded in natural and exact sciences and 465 doctors' degrees in engineering and technology. It has been estimated that between 1971-75, there will be 4,600 doctoral degrees granted in mathematical, physical, chemical, and other natural sciences, and about 4,300 doctoral degrees for the technical sciences. Powers for awarding doctoral degrees were vested in 248 institutional units in 1969; this number included 189 faculties and institutes in the schools of higher education, 29 institutes and research centers of the PAN, and 30 research institutes of the ministries. In January 1969, approximately 1,350 research workers had been admitted to doctoral studies; 36% of them were registered with the ministerial research institutes.

The PAN and formerly the KNiT have been responsible for forecasting manpower needs and developing plans to secure an adequate supply of qualified scientific and technical personnel. A commission including the above organizations and the Ministry of Science, Higher Education and Technology works on scientific personnel development plans extending to 1985. The previous shortage of qualified scientists and technicians has become less acute, and the major research centers and installations are well staffed. Industrial enterprises apparently are unable to absorb a large number of the students with advanced training in science and technology. Most of these graduates take jobs in governmental research institutes or in higher educational institutions.

The quality of Polish scientific and technical manpower is variable. During the years 1949-54, the technical universities concentrated efforts on the mass training of specialists in narrow fields in order to fill the shortage of qualified personnel. As a result, many unqualified personnel, particularly in engineering and medicine, were produced. In subsequent years there was a return to the philosophy of a thorough basic education at the expense of specialization, with a consequent improvement in the quality of scientists and engineers.

According to recent statistics, there were about 6,050 chemists with university degrees and about 6,300 qualified chemical engineers in Poland in 1970. About one-half of the chemists and one-third of the chemical engineers are women. A concerted effort is underway to encourage students to study chemistry and related subjects, but in 1971 the number of students studying mathematics and physics unaccountably increased while there was a decrease in chemistry students.

Polish scientists are poorly paid; consequently, many hold more than one position. For instance, some salaried workers of PAN institutes also are employed by universities or higher technical schools. The government is attempting to limit scientists to one position by increasing their salaries.

The Polish Government realizes that much of the country's progress in research and development is impeded because of inefficient use of qualified manpower and the fact that Poland lacks modern and advanced facilities for conducting the needed research. The main contributing factor has been the low level of foreign exchange earnings which has prevented the government from buying better equipment abroad. During the past 25 years, research centers have increased their apparatus, facilities, and machinery necessary to carry on their short- and long-range programs; however, much of the equipment is either improvised or poorly made. Most of the best

equipment is located at the various institutes of PAN. The university research laboratories lack much of the latest research equipment, but when conducting research for the PAN, the university investigators have easy access to PAN equipment. The Polish Government especially encourages joint research projects with counterparts in other countries which have good experimental facilities, regardless of whether they are in Eastern or Western Europe. Probably the best equipment Poland has is located at the Institute of Nuclear Research. It has ion integrators, nuclear research reactors, glass (neodymium) lasers, mass spectrometers, and an improved CDC 6400 "Cybor 72" computer. Polish industry has developed equipment for conducting spectroscopic-related research. The Poles have designed and constructed a highpressure reaction vessel for studies of electroparamagnetic resonance and cryogenic equipment for superconductivity developments.

D. Major research fields

1. Air, ground, and naval weapons (S)

Poland has attempted only limited development and production of native weaponry and material. As a result, the country has not developed the expertise and experience needed to plan, initiate, and manage the research and development of advanced weapon systems. Much of the weapon-related research that Poland does conduct is directed toward supporting Soviet classified programs, although the country receives little reciprocal support from the U.S.S.R.

Research and development capabilities are strongest in the aerospace field but are limited to the design and production of light transport and jet trainer aircraft, helicopters, and meteorological rockets. Although Poland lacks the necessary research base to develop and produce advanced aircraft systems, its aeronautical industry is, nevertheless, very active and remains an important sector of the national economy. Poland is a principal supplier of jet trainer and general aviation-type aircraft, engines, gliders, and aircraft instruments to Warsaw Pact nations and also exports to at least 40 other countries.

A new long-term agreement between Poland and the U.S.S.R. signed in 1972 indicates that Polish aircraft development capabilities can be expected to improve significantly during the coming decade. The agreement provides for mutual cooperation between the two countries in the design, manufacture, and marketing of aircraft. The reported terms of the agreement also indicate a growing emphasis on indigenous Polish design and development of certain types of aircraft, with Soviet technical assistance, and a corresponding decline in the licensed production of Soviet aircraft in Polish factories. Light aircraft for agricultural and general utility roles, helicopters, gliders, and powered gliders will be emphasized in the new program. It appears unlikely that Poland will develop a capability for advanced aeronautical research and development beyond that required of a light aircraft industry. Since 1969 activities in the aeronautical sciences have been of an academic nature with emphasis on theoretical investigations of boundary layer formation and heat transfer in supersonic flow. Shock tubes are used in the investigations, and the work appears to be broad in scope but with no apparent direct application to weapon system design.

Polish research in rocket-associated technologies has been confined to the development of solid propellant motors for artillery and meteorological applications. Emphasis has been on double-base propellants. Generally, combustion research of a fundamental nature has been carried out at the universities, while most of the applied work has been accomplished at the Aeronautical Institute. Studies in liquid propellants are limited.

Although the U.S.S.R. has successfully discouraged Poland from establishing an independent missile research and development capability, the country, nevertheless, has derived some technical benefits from the Soviet missiles that are deployed operationally in Poland. These include the surface-to-air GUIDELINE and GOA missiles and quite possibly the GANEF system; the shore-to-ship SAMLET; the ship-to-ship STYX; and the antitank SNAPPER, SWATTER, and SAGGER systems.

Poland has only a meager capability to undertake the design and development of space systems. Space-related activity is limited to the development and launching of upper atmospheric sounding rockets and ground-based observation of rockets, as well as foreign-launched earth satellites. Besides developing the Meteor series rockets, Poland has designed and produced equipment for use in Soviet-launched geophysical vertical probes. This equipment consists of X-ray spectroheliographs and a system of X-ray pinhole cameras.

There are 12 optical satellite ground tracking stations being operated by the Polish Artificial Earth Satellite Observation Service. Initially, these stations were capable only of making and reporting observations; however, they can now accomplish some analysis and evaluation of the collected data. Information and data obtained from these stations are

forwarded to the Soviet Kosmos data center in Moscow.

Poland has a minor capability for research and development of ground force weapons and has apparently not achieved any highly significant results. Poland and Czechoslovakia have collaborated on an 8-wheeled amphibious armored personnel carrier (APC), the OT-64 series. This APC fulfills the same function in their armies as the BTR-60P series in the Soviet Army. Initially, vehicles of this series were equipped with a truncated cone turret of Soviet design. This turret did not provide the desired antiaircraft defense for their field forces and was redesigned by the Poles to provide an increased antiaircraft capability. The Poles are not known to be active in research and development on tanks and self-propelled guns. Some research is underway on transport vehicles and engineer and quartermaster equipment. Poland has only a modest capability for research and development of military transport vehicles. At present, the country is heavily dependent on the Soviet Union for its military transport fleet, importing a wide range of vehicles. Engineer-type equipment on which significant research has been accomplished consists of bridging and stream-crossing equipment and topographic instruments. Polish Army engineers have recently developed a new ribbon bridge, designated PP-64, and a bridge erection boat, designated KH-200. In the field of air-cushioned vehicles, Poland has an extensive program underway, second only to the U.S.S.R. among the Communist countries. Model testing is emphasized and a few small skirted prototypes for civilian applications have been built.

In the development of topographic instrumentation, Poland has a small but significant research and development capability in comparison with other Warsaw Pact countries. The Poles are highly accomplished in the development of electronic-geodetic distance-measuring equipment. Their latest model, the RG-10 (Figure 2), is a fully transistorized radio distance-measuring instrument and is used for precision geodetic surveys. It was adapted and tested successfully in 1970 for hydrographic operations. To this equipment was added in 1972 two new electro-optical geodetic distance-measuring instruments, the telemeters PA1 and DN1. These are of military interest because their radiation is in the invisible infrared. There also has been military involvement in the development of experimental image conversion devices for standard optical surveying equipment to enable their use at night with targets that either radiate in the invisible infrared (passive systems) or

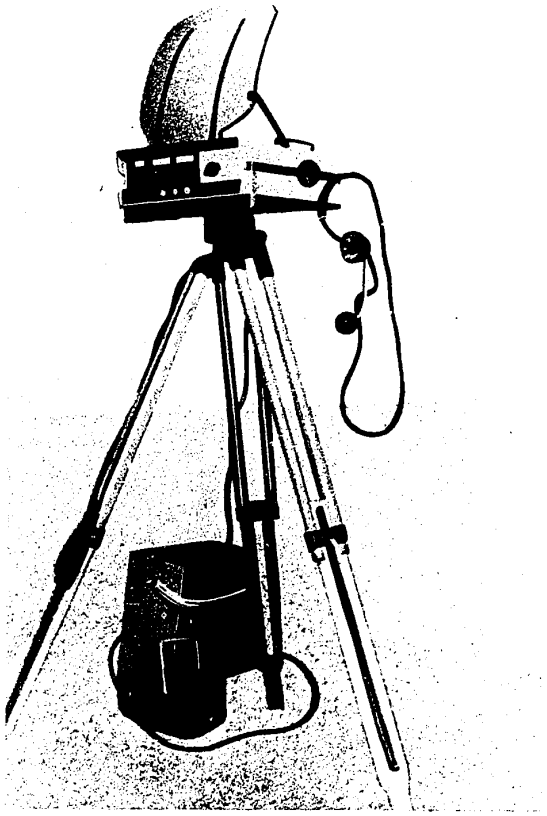

FIGURE 2. Polish-developed telemeter (U/OU)

which are eliminated by projected infrared light (active systems). The rather active Polish research and development program for medium- and small-capacity computers has led to the development of two small special-purpose computer models for geodetic computations. Some research is underway on military clothing and individual equipment, including such items as combat camouflage clothing for ground and airborne troops; garments and helmets for aircrews and tankers; and a multipurpose poncho-type garment for chemical, biological, radiological, and environmental protection.

The Poles continue to demonstrate a competency to design and produce amphibious landing ships, small combatants, and miscellaneous naval auxiliaries. The country has designed and built a number of amphibious landing ships, oceanographic survey ships, and auxiliaries for use in the Soviet and other Communist Bloc navies. Research is underway on plastic hull construction and gas turbine propulsion. Poland is the most active East European country in the design and manufacture of diving and underwater

salvage equipment, and manufactures a number of Western marine diesel engines under license.

2. Biological and chemical warfare (S)

Biological warfare (BW) and chemical warfare (CW) research and development programs are conducted under the auspices of the Ministry of National Defense. The Polish chemical industry ranks third among East European Communist countries and is potentially capable of supporting an expanded research and development effort. Many Polish institutes conduct research on subjects peripheral to CW, and at least three have reported, in open literature, some scientific work with direct CW implications: the Technical University of Lodz, and the WAT and the Military Institute of Aviation Medicine, both in Warsaw. Currently, there are no positive indicators of offensive BW research in Poland, but activity directed to that end could readily be obscured and integrated in the existing programs of modern Polish institutes. Polish bacteriologists and virologists maintain contact with highly competent counterparts on an international level and keep abreast of developments in their field.

Poland has the facilities and personnel to conduct limited offensive and defensive BW research and development. Offensive BW research was conducted as early as 1957 on the infectivity, virulence enhancement, and antibiotic resistance of microorganisms causing tularemia, plague, typhus fever, brucellosis, cholera, anthrax, encephalitis, Q-fever, rabies, and foot-and-mouth diseases. The work was directed by the Polish Government on orders from the U.S.S.R.

Current research areas in biochemistry include oxidative phosphorylation, nucleic acid metabolism, cancer research, protein biosynthesis, toxicology, new diagnostic testing, energy transfer in microbial systems, and viral nucleic acids. Selected advances in knowledge and technique derived from these studies could be utilized for BW purposes. Polish investigators have recently published the results of quality research on staphylococcal enterotoxins, arbovirus isolations, tick-borne encephalitis culturing, growing and harvesting free Shigella endotoxin, and scrub typhus epidemiology, which could also have BW application. A recent advance at the Warsaw Medical Academy in bacterial transformation involving a double protein competence-provoking factor may have BW application in making it possible to introduce virulence or drug resistance into otherwise harmless microorganisms.

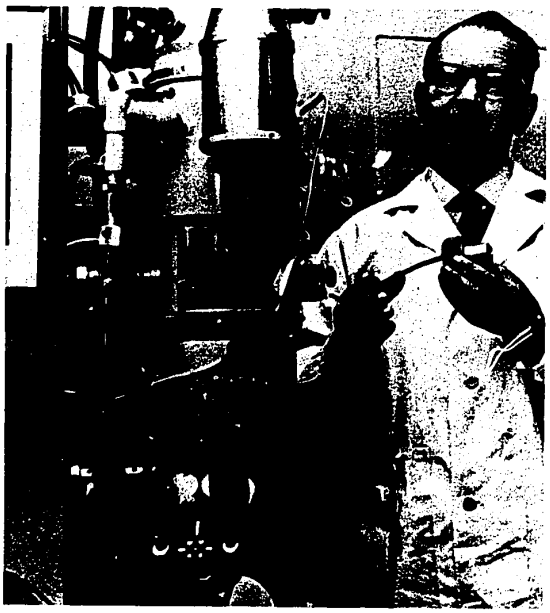

FIGURE 3. Prof. Stephen Slopek, Director of the Institute of Immunology and Experimental Therapy, Wroclaw, with the electron microscope (U/OU)

Prof. Stephan Slopek, Director of the Institute of Immunology and Experimental Therapy, Wroclaw (Breslau) (Figure 3), was reported at that post as recently as 1971. During early 1972, however, Prof. Slopek was identified with the Veterinarian and Bacteriological Institute in Pulawy. This institute probably is the same as the State Veterinary Institute. Information obtained in August 1972 revealed that the Pulawy facility is well staffed and well equipped to conduct both offensive and defensive BW. After many years as a recognized expert on bacillary dysentery, Prof. Slopek's work at Pulawy has taken an unusual turn in that he is now working on the transformation of bovine staphylococci with the aid of T bacteriophages. Genetic manipulation of any pathogen could enhance its resistance to therapy, its stability to environmental effects, and/or alter its host range. Ostensibly, research in the laboratories of this institute appears to be directed toward the prevention and cure of veterinary diseases, but it could readily apply in all of its diversity to a BW program.

At the same time that offensively oriented BW research was begun in 1957, Poland also began an accelerated program of BW detection, identification, and rapid diagnosis. All conventional and sophisticated techniques have been investigated by the Poles for this purpose. In late 1970 an article in the Polish

journal *Military Physician* discussed the prospects for rapid microbiological diagnosis of diseases caused by BW agents. The Military Institute of Hygiene and Epidemiology found that more rapid growth of bacterial cultures resulted when cytochrome C and amino acids were added to the conventional medium. Such growth cut down on identification time but it was by no means an "express method" because traditional methods were required after obtaining the initial isolate. The article reviewed research done with indirect hemagglutination reactions, immunofluorescence, indirect immunofluorescence, and virus sampling procedures by which pathogens were propagated in either young animals or in tissue culture. It was found that there were many problems to be resolved in rapid BW identification and diagnosis, particularly with viral agents. The article cautioned that regardless of the rapid methods envisioned for use in field laboratories, all results should be confirmed by using conventional methods. Further, it was stated that in some instances virulent strains of microorganisms may give negative results when the rapid method is tried; therefore, only conventional methods remain for identification. Polish findings in these areas are the same as those reached in the West at this time.

The infection of food and other crops is a subtle but economically significant form of BW. Reports indicate that the Poles are achieving a good capability in defensive anticrop BW. Their crop infectivity and susceptibility experiments also could be exploited for offensive purposes if necessary.

Offensive research on toxic chemicals is concerned chiefly with organophosphorus compounds and bacterial toxins. Polish scientists are competent, have performed some excellent work in these fields, and have acquired a very good potential for the development of nerve agents. Research has been conducted with botulinum toxin, one of the most toxic substances known; scientists have isolated a culture from *C. botulinum,* Type F, that is capable of producing a toxin 10 times more lethal than the parent strain. Antigenic analysis of the toxin showed a serological relationship with botulinum toxins, Types B and E. Poland is not known to have conducted research on new types of equipment or methods for dissemination of CW agents. Flame and smoke warfare research is negligible.

Defensive CW research is directed primarily toward therapeutic agents, with some effort toward protective clothing. Work is underway on the detection of and immunization against botulinum toxins. Research is being conducted on new therapeutic drugs to combat nerve agents and antimetabolite poisoning, as well as studies on the mechanism of action of therapeutics and prophylactics in nerve agent poisoning. The therapeutic use of pyridinium aldoxime methiodide (PAM) for toxic doses of organophosphorus compounds was found to be more effective when used with atropine sulfate. Polish scientists continue to conduct research along these lines in an effort to develop improvements in this method of treating nerve agent casualties.

The Polish Army continues CW research and development work on decontamination vehicles and protective masks. As a result of Polish research, the IRS decontamination vehicle was modified to fit Polish needs. This improved vehicle was first supplied in 1970 to Polish Army chemical troops to replace Soviet decontamination vehicles. Also, Polish Army researchers have developed the new R-20 protective mask with reduced bulk and improved breathing. It is probable that the Polish R-20 protective mask is a copy of the Czechoslovak M-10.

3. Atomic energy (C)

Poland has a modest nuclear energy program commensurate with the technical and industrial capabilities of the country. Efforts in basic and applied research are rather limited but there is an extensive program on the applications of radioactive isotopes. The long-range objective of the program is the development of the economic uses of nuclear energy, particularly for power production. Poland has essentially no capability to develop nuclear weapons, and its nuclear program will be under the safeguards system of the IAEA under the terms of the Non-Proliferation Treaty.

The nuclear energy program began in 1955 with the conclusion of a bilateral agreement with the U.S.S.R. through which the Poles acquired a research reactor and a cyclotron and received assistance in training personnel. Poland also has benefited from its membership in the Joint Institute for Nuclear Research at Dubna in the Soviet Union. It has concluded bilateral agreements for cooperation in the nuclear field with a number of countries and carried out a program for reactor research with Norway and Yugoslavia under the auspices of the IAEA.

In June 1955 the Polish Government established the Institute of Nuclear Research (IBJ) under the auspices of the PAN. The IBJ has research facilities in Swierk, Warsaw, and Zeran, and a laboratory at Lodz. Overall direction of the nuclear program is given by the High Commissioner for Atomic Energy.

The Swierk center is the site of the Soviet-supplied research reactor, EWA, a tank-type reactor which went into operation in 1958 with a design power level of 2 megawatts thermal (MWt) with 10% enriched uranium fuel. With changes in the cooling circuit and the use of higher enriched fuel, the power level of EWA was increased to 4 MWt in 1964, to 8 MWt in 1967, and to 10 MWt in 1969. Other facilities at Swierk are a zero-power exponential assembly for reactor physics studies, called HELENA; a 100-watt graphite-moderated critical assembly, ANNA; and a 10-kilowatt pool-type reactor, MARLYA. ANNA was used in a joint Polish-Norwegian-Yugoslav research program. MARYLA is a prototype of a university-type training reactor and was used to study the different fuels used in EWA. In September 1969 construction was started on a high-flux materials testing reactor that is expected to go into operation in 1974 with a power level at 30 MWt. This reactor, named MARIA, will be operated for several years at 30 MWt level but is expected to be increased to 60 MWt later.

In addition to the reactors, the Swierk site has a 34 million electronvolt (MeV) betatron and a 10-MeV proton linear accelerator. A linear electron accelerator, which provides energy ranging from 4 to 18 MeV, was supplied by the Soviet Union to the IBJ center in Zeran in November 1972. This accelerator is to be used to develop processes for the sterilization of medical equipment.

The IBJ has subordinate to it a Department of Solid-State Physics; a Department of Plasma Physics and Technology, which is carrying out a program for the development of magnetohydrodynamics; and a special Center for Isotope Production and Distribution. All are located in Warsaw, although the isotopes are produced in the reactors at Swierk.

Nuclear research also is underway at the Institute of Nuclear Physics (IFJ), formerly a component of IBJ, at Bronowice near Krakow. The principal facilities of the IFJ are a 12.5 MeV (proton) Soviet-supplied cyclotron, and a Polish-made 4 MeV Van de Graaff accelerator. The IFJ is concerned primarily with nuclear reaction problems and studies of the structure of atomic nuclei. The Lodz center of the IBJ carries out studies in radiation chemistry, and a small group is studying cosmic radiation in an underground laboratory for the detection of high-energy mesons and photons. In addition, most of the universities and technical schools and a number of industrial and governmental organizations conduct nuclear research. The office of the High Commissioner for Atomic Energy has direct responsibility for several specialized organizations, including the Central Laboratory of Radiological Protection and the Trust for the Production of Nuclear Equipment, formerly named the Bureau for Nuclear Equipment. Both have headquarters in Warsaw.

The principal Polish application of nuclear energy is the use of radiation or radioisotopes for research, medicine, and industry. A program for the development and production of equipment using radioisotopes is carried out by the Trust for the Production of Nuclear Equipment. The industrial equipment includes devices for nondestructive testing and process research and control. For example, a betatron with a maximum energy of 33 MeV has been installed in the plant laboratory of the Polkowice mining plant for the automatic determination of the copper content of the plant concentrates. The betatron was produced by IBJ, but most of the equipment is produced in the Trust for the Production of Nuclear Equipment plants in Bydgoszcz, Katowice, Krakow, Poznan, Sluzewiec, Szczecin (Stettin), and Zeran.

During 1970 Poland undertook a study of the prospects for nuclear power. Original plans called for the construction of a 1,000-megawatt electric (MWe) nuclear power station in the Gdansk area by 1980. In 1972 a program developed with the aid of the U.S.S.R. called for the construction of the Soviet 440-MWe Novovoronezh pressurized water type power reactor to go into operation between 1980 and 1982. An additional 1,000-MWe nuclear power capacity is to be added later. A site has been selected near Gdansk; cooling water for the reactor will come from Jezioro Zarnowieckie.

Polish uranium ore is of low grade. Poland supplied minimal amounts of uranium ore to the Soviet Union until 1958 when the operative agreement was not renewed. The IBJ at Zeran has been attempting to develop economic means of extracting uranium from the low-grade ores and has a small pilot plant for uranium concentration. The Institute of Nuclear Technology of the Academy of Mining and Metallurgy, Krakow, also is interested in developing methods of detecting uranium ores. The fuel for the reactors in operation at Swierk has been supplied by the U.S.S.R., and it is expected that the Soviets will furnish the fuel for the reactor under construction and the planned nuclear power reactor.

4. Electronics (S)

Electronics research and development programs are modest and of limited international significance. The programs are hampered by shortages of technical personnel, facilities, and high-purity raw materials. It is only in the development of radar equipment,

computers, and lasers that Poland has shown excellence. Some good work has been done in other areas, including wide-band communications, semiconductors, thin-film techniques, ceramics, and color television.

Considerable effort is being devoted to the development of various types of radar, including marine, air search, and height-finding radars. By international standards, Polish radar technology is well advanced. The Poles appear to place major emphasis on the development of ground and shipborne radar sets, relying primarily on Soviet designs for airborne installations. The marine electronics industry has attempted to reverse the need for relying upon equipment purchased from abroad and has developed a second generation transistorized marine radar, the RN-231. It is similar in appearance and operation to the U.K. Decca radar navigation system and has met with some success after prolonged shipboard tests. It does not exhibit any advances over other systems, however. A civil air-route surveillance radar developed in 1966, the Avia-B, incorporates a moving target indication capability, an important sophistication for conformity to standards set by the International Civil Aviation Organization. Another notable achievement was the development in 1967 of a millimeter-wavelength, high-resolution radar for airport and harbor surveillance. In some areas, Polish radars incorporate a measure of sophistication probably not employed in Soviet air-surveillance radars. In addition, an air-surveillance and a height-finder radar were developed in 1967 and 1968, respectively, for use by the air defense forces in Poland.

The Microelectronics Department of the WAT is concerned with the development of microelectronics and in 1967 produced an electron-phonon amplifier for converting supersonic impulses into electronic impulses, claiming to be the first to build such a device. Polish scientists have presented papers at recent international conferences and since 1970 apparently have been doing work on microamplifiers of hundreds of megahertz with many stages on one substrate using pi circuits (a 3-element network) for tuning. Considerable interest is being shown in Western technology.

The Warsaw Polytechnic Institute is developing infrared detectors and associated subsystems, including an infrared target seeker for missile guidance. The sensing device of the subsystem consists of four infrared detector cells. A correction signal is generated for the guidance system when the radiation does not fall equally on all four cells. The cells probably are lead sulfur or lead selendes, since the Institute of Physics in Warsaw has done considerable work with these materials.

The Polish laser research and development program, one of the most active in Eastern Europe, is a key category within the Five Year Plan for the scientific and technical development of electronics and communications. A separate coordination plan for the program is directed by the Institute of Quantum Electronics, under the WAT, which is responsible for types of laser research having potential military application. The institute conducts research and development and acts as coordinator for several other research facilities in the development and production of laser equipment, materials, and subassemblies. The institute has cooperated with East Germany in resolving several related problems and is establishing areas for a cooperative effort with the U.S.S.R.

During 1969 a project was underway to convert aircraft radar echos into black and white aerial reconnaissance photographs for real-time display and evaluation at headquarters, using computer processing and television-type display. Research on radar camouflage techniques reportedly has been done at the Wroclaw branch of the Industrial Telecommunications Institute, Warsaw. A classified project is underway at the Gdansk Technical University on electronic support measures and has concerned the development of a receiver capable of automatically scanning the D-, E-, F-, H-, and I-bands and of measuring the frequency and pulse widths of radar signals.

Much of the Polish electronics research effort has been devoted to work on semiconductors. Poland has an advanced tube technology, particularly in high-power tubes, but it lags the West in the development of semiconductors. Because of the high impurity levels in their domestically grown crystals, the Poles usually import silicon crystals and wafers from abroad. Semiconductor research is oriented heavily toward computer applications. The Institute of Tele-Radio Research, Warsaw, has been making hybrid integrated circuits since 1968, and the MORS (*Morska Obsluga Radiowa Statkow*) plant, Gdansk, was conducting intensive research on circuits utilizing large quantities of monolithic and hybrid integrated units in 1969.

Since 1971 Poland is believed to have been assigned primary responsibility for the major solid-state research and development effort within the Warsaw Pact. The largest semiconductor manufacturer in Poland, TEWA, in Warsaw, has purchased technology and facilities from France and the United Kingdom. The WAT in Warsaw undertakes considerable

research and development of electronic devices. The director of WAT, Gen. J. S. Kaliski, is Deputy Minister of National Defense and a full member of the PAN.

Poland is one of the few Communist countries that openly discusses military applications of television. In 1966 the Polish Army displayed portable manpack television surveillance systems that consisted of cameras and transmitters and were intended for use at tactical command posts. In late 1970 the Alpha-3 transistorized closed circuit television system was being studied by the army for training and for field use. This prototype system apparently was produced at the Warsaw Television Factory.

The Quantum Electronics group of the Institute of Electron Technology and Research at the Warsaw Polytechnic University has a substantial laser research and development program. The group utilizes many types of operational lasers, including argon and krypton ion lasers, transversely excited atmospheric (TEA) lasers, and neodymium-glass lasers. Research also is conducted at the Institute of Physics of PAN, the universities of Wroclaw, Poznan, Torun, and several other scientific institutions. Gas dynamic lasers are also under development.

Research begun in 1966 at the Warsaw Polytechnic Institute led to the design of the ML-1 laser microtool. It is used for welding and drilling and has application in thin film and integrated circuits technology. The Poles have built lasers since 1963 with domestically produced materials, and have conducted laboratory experiments in modulation and detection of laser beams. A precision linear measurement system was to be completed early in 1970, using a continuously operating gas laser with a small digital computer to produce the results. Lasers constructed since 1963 include ruby, helium-neon, semiconductor types, and a carbon-dioxide gas dynamic unit operating at a continuous power level of 1 kilowatt.

High priority is accorded optics research; the present Five Year Plan (1971-75) includes development of a modern optical glass facility. The Industrial Institute for Electronics conducts research in ceramics, glass and electronics, and manufactures radios and radars, mainly for the Polish Army. Poland proposed to effect the transition to totally transistorized communications equipment by 1970, including the national telephone/telegraph system, but the plan has not been realized fully. The Poles are considering integrated digital communications systems.

Poland has a considerable interest in the development, manufacture, and use of computers, and ranks next to the U.S.S.R. among the European countries in computer capabilities. The laboratories of the Wroclaw Electrotechnical Works (ELWRO) has been successful in translating new machine designs into industrial production models and is the leading facility for development of production models of computers. ELWRO is the most successful computer producer in Poland, producing both digital and analog machines. The plant developed and produced the ODRA series of machines, which was the first East European model for which complete servicing provision was specified. ELWRO received considerable assistance from British International Computers, Ltd., in the design of the ODRA models 1304 and 1314. In the cooperative U.S.S.R.-East European Communist country plan for an IBM-360 compatible development of a series of computers, called the Ryad or ES series, Poland is responsible for the model 30. Originally responsible for the software, Poland now has been assigned responsibility for peripheral and other hardware as well.

The Institute of Mathematical Machines (IMM) has displayed strong capabilities in basic research on logic design and in the development of new programing languages and automatic programing techniques; some of the results have been adapted by the U.S.S.R. The only model that has achieved production status in Poland is the UMC-1 vacuum tube model. A number of more recent development is the ZAM series. The most recent is the ZAM-51 prototype, which has a design sophistication that appears to be beyond Polish production capabilities. Measuring Instrument Works in Warsaw has shown an interest in further development of disc storage drives and cathode ray tube terminals and is attempting to market its minicomputer, the K-202, which is built with Western components. It uses integrated circuitry and reportedly has a per operation rate of 2 nanoseconds. The Poles are experiencing difficulties in preparing second- and third-generation computers because of delays in mastering production techniques and solid-state technology. Relatively strong emphasis is placed on acquisition of Western technology to produce electronic data processing systems and components.

The application of computers includes their use in data processing for economic planning and accounting, as well as in problem solving to support military, scientific, and industrial projects. The number of computers in the country increased from 100 in 1967 to more than 140 in 1968. In 1966 the government instituted a national program to establish computing centers throughout the country under the direction of the Organization of Electronic Technical Computers (ZETO). The purpose of the program is to

promote industrial production by establishing large computing centers in strategic locations for the use of all agencies, research and development institutes, and production and commercial installations. About 14 centers have been established and appear to be operating. The government is planning to establish a computer center called CYRONET in Swierk to provide advanced scientific computation facilities for the Warsaw community. Initially, there are to be 11 terminals in Warsaw institutes and schools. Other regional centers are planned.

5. Medical sciences (S)

Polish biomedical scientists are making relatively few contributions to medical knowledge, but those that are made are of good quality. The government does not place a high priority on medical and biological research and progress is hampered by shortages of funds, facilities, and equipment. Much needed support is furnished by Western governments and foreign foundations. In an effort to improve its research position, Poland is committing foreign currency to acquire advanced research laboratory equipment. In addition, study abroad, especially in the United States, by biomedical scientists is encouraged. Biomedical research is directed by the Ministry of Health and Social Welfare, the PAN, and universities; the PAN is expected to assume a role in coordinating the research. Emphasis in biomedical research is being placed on practical problems of improvement of health care, advancement of pharmaceutical research, and protection of the environment. Achievements have been made in environmental physiology, microbiology, hematology, and molecular biology.

Physiologists have stressed studies on the adaptation of the human body to the environment and to conditions of work. Some good electronic instrumentation has been developed to assist in determining the parameters of performance of mechanical tasks and to register the effects of noise and heat on the health of workers in selected occupations. The Nencki Institute of Experimental Biology of the PAN in Warsaw has produced excellent apparatus for study of night and color vision and is doing superior research on coronary circulation. The Poles have established a comprehensive research and research training program in orthopedics and powered prostheses and in rehabilitation of the disabled.

Research in hematology is traditionally of high caliber. Research is devoted to the diagnosis and therapy of blood diseases, especially hemophilia, and to the refinement of blood donor systems. Hematological studies are undertaken in cooperation with the countries of Eastern Europe.

Microbiological research is, in some limited areas, on a par with that done in the United States. Biochemical, radiological, and physiological techniques are being employed by workers at the State Institute of Hygiene, Warsaw, in the study of the neural action of toxins isolated from staphylococcic organisms. Controlled epidemiological study of the efficacy of vaccines is being utilized in the selection of the most promising for large-scale vaccination programs. The technology of research in immunology has been carefully developed and refined to assist research workers in the analysis of the phenomenon of resistance to diseases. The Poles are carrying on excellent research in immunological diagnosis of infectious diseases. Environmental studies are underway to control water pollution in the Vistula River.

Biochemical research reflects international interests and approaches, and research personnel have been trained abroad. Research is being devoted to the structure and function of proteins and to the molecular basis of resistance to infection. In work confirmed in the United States, scientists at the Biochemistry Department of the Hematology Institute and the Immunopathology Department of the State Institute of Hygiene have shed some light on the structure of the Australian antigen. The Institute of Molecular Biology of the Department of Biophysics, Krakow, has developed advanced competence in the observation of vital constituents of cells and tissues. The Poles have demonstrated interest, stimulated by Western work, in the role of biogenic amines, for example, serotonin and its derivatives, and in the etiology of mental disturbances. Attention has been directed to the application of lasers in ocular surgery and to examination of the neurological effects of exposure to microwave radiation.

An effort is being made to improve the Polish pharmaceutical industry. Research is underway in support of the production of antibiotics and of psychotropic agents, vitamins, hormones, and anti-inflammatory agents. The Institute of Organic Chemistry of the PAN has synthesized a derivative of erythromycin, an antibiotic of considerable clinical importance. Arterial hypotensive agents and psychotropic drugs have been given particular attention by Polish pharmacologists.

Research in radiation is a relatively new field for scientific investigation in Poland, but it is developing steadily. Excellent work has been devoted to study of the mechanism of ionizing radiation and its effect on

the production of cellular energy, bone calcium, and tumorous cells. The Department of Radiology of the Gdansk Medical Academy has contributed to pneumoencephalographic identification of organic changes in the brain of drug addicts. Environmentalists have studied the effects of natural radioactive isotopes and toxic substances released into the atmosphere by fuel consumption in power plants.

Military medical research is under the direction of the Ministry of Health and Social Welfare; its liaison office with the army is staffed entirely by military personnel. The overall planning of triservice military medical research is performed by the Scientific Research Division, Health Department, Polish Armed Forces. Military medical research facilities are better equipped than civilian facilities and have qualified personnel; however, civilian resources also are used extensively for military medical research, probably for political reasons, and the results of all medical research are automatically made available to the armed forces.

Two important military facilities engaged in biomedical research are the Military Institute of Aviation Medicine (MIAM), Warsaw, and the Central Institute for Air Medical Examinations (CIAME), Otwock. These facilities conduct research on operational aviation medical problems, including the design and use of personnel protective devices, physiological conditioning, physical training, hypoxia, altitude adaptation, and selection criteria. Since 1960 the Military Institute of Aviation Medicine has contributed basic research toward the Soviet manned space program on the effect of weightlessness and possibly also on human factors research relating to spacesuit design. The General Karol Kaczkowski Military Institute of Hygiene and Epidemiology, Warsaw, and the Military Medical Academy, Lodz, also perform research for the services. There is a continuing exchange of space medical personnel with the U.S.S.R.

6. Other sciences (S)

a. Chemistry and metallurgy

Poland has a broad and well-balanced program of chemical research. Most of the important branches of chemistry are covered in depth, with the greatest strength in organic chemistry. The country has a large number of facilities, both educational institutions and research institutes, which conduct fundamental and applied chemical research. Because of the country's interest in developing the organic chemical, pharmaceutical, synthetic fiber, petrochemical, plastics, and fertilizer industries, applied research is receiving increasing emphasis, but important fundamental chemical research is continuing. Poland has a number of outstanding chemists who have obtained worldwide recognition for their achievements in special fields.

Several of the higher educational institutions and research institutes are strong in synthetic organic chemistry and in the study of organic chemical reactions. The Technical University of Warsaw is doing important work on the synthesis of organic nitrogen and boron compounds, heterocyclics, and antituberculosis drugs. Involved in the research at the university is Prof. Tadeusz Urbanski (possibly now in semiretirement), one of Poland's most outstanding chemists. He is noted for his synthetic studies and his extensive work on the preparation, properties, and reactions of organic nitro compounds, including explosives. The synthesis of pharmacologically active organic compounds is a subject of particular interest at the Pharmaceutical Institute, Warsaw, and the Medical Academy at Warsaw. Jan Michalski, Professor of Organic Synthesis, Technical University of Lodz, heads an active group which works on substituted pyridines and organic phosphorus compounds (especially those containing sulfur and selenium atoms). Organic chemists at the University of Lodz have been concerned with significant work on the synthesis of aminoalcohols, heterocyclic nitrogen and sulfur compounds, and in the use of the Mannich reaction for the synthesis of heterocyclic systems. There is a substantial amount of organic research related to natural products. Thus, the University of Warsaw does research on steroids (including the synthesis of nitrogen analogs), terpenes, and sugar derivatives; the PAN institute of Organic Chemistry, Warsaw, does work on steroids and monosaccharides.

A good capability exists in physical organic chemistry. Michalski's interests at the Technical University of Lodz extend to organic reaction mechanisms and stereochemistry. Research at the Technical University of Warsaw is strong in reactions of nitroparaffins and organic anions and in reaction mechanisms generally. The Institute of Organic Chemistry has an outstanding capability in physical organic chemistry and does work on nuclear magnetic resonance, steric effects, isomerization, and infrared spectra and structure of substituted unsaturated carbonyl compounds.

There is considerable organic chemical research related to the country's plans for large increases in production of synthetic fibers, plastics, pharmaceuticals, agricultural chemicals, and other organic products. Petrochemical research and development

have been stimulated by the large oil refinery and petrochemical plant at Plock, which supplies a large part of the Polish requirements for petroleum products and chemicals. However, in an effort to make Poland largely self-sufficient in the production of chemical products by 1980, the country is acquiring licenses for advanced chemical technology from many foreign countries. Research on high polymers is underway at several locations, including the Technical Universities of Lodz and Wroclaw and the Organic Synthesis Research Institute at Blachownia Slaska, but Poland has made only modest contributions in this field. For some time, most polymer technology has been imported.

In physical and inorganic chemistry, there is a strong effort in catalysis and inorganic reaction mechanisms under Alfons Krause at the Adam Mickiewicz University in Poznan. Krause and his coworkers have accounted for a great number of publications on homogeneous and heterogeneous catalytic reactions, inhibitors of catalytic reactions, development of catalysts for commercial processes, and reaction mechanisms, both catalytic and noncatalytic. Considerable recent work by this group has been concerned with decomposition of hydrogen peroxide solutions in the presence of various metal ions. There is some fundamental research in electrochemistry at the University of Warsaw, including studies on polarographic reduction. Dr. Wiktor Kemula at the Institute of Physical Chemistry, Warsaw, who has a permanent staff of about 20 persons, is recognized internationally for his work on polarography, chromatography, and potentiometric titrations. Much of his work has dealt with the hanging mercury drop electrode. He and his associates have developed many techniques in instrumental analytical chemistry, including a polarographic method of monitoring chromatographic separations. Most of the universities and technical universities engage in some inorganic chemical research. The Institute for Inorganic Research at Gliwice, under the Ministry of Chemical Industry, conducts research on artificial fertilizers, and several of the agricultural colleges are concerned with soil chemistry.

The Institute of Nuclear Research, Warsaw, has a considerable interest in isotope production. It does research on chromatographic separations, solvent extraction, and lanthanide and actinide chemistry. This institute is active in analytical research, including activation analysis studies. The Institute of Nuclear Physics, Krakow, engages in research on solvent extraction and partition chromatography and on organic analytical reagents for metal analysis. Scientists at this institute are capable in research on neutron activation analysis and X-ray fluorescence analysis.

Outstanding research in analytical chemistry is done by Prof. Zbigniew Gregorowicz at the Technical University of Silesia at Gliwice. He and his collaborators have done extensive work in development of titrimetric, spectrophotometric, and gravimetric techniques, oxidation-reduction indicators, and methods for determining rare metals.

Research in biochemistry is increasing in importance but is less highly developed than other branches of chemistry. The PAN Institute of Biochemistry and Biophysics, Warsaw, does research on nucleic acids, lipids, and protein biosynthesis. Investigators at the University of Lodz are doing research on protein and nucleic acid synthesis and on hemoglobin. Several of the Academies of Medicine engage in a variety of biochemical research projects. Among the East European countries, Poland has one of the most active programs in deterioration of materials, its causes, and preventive techniques. Researchers participate freely in a data exchange program administered through the Biodeterioration Information Center in the United Kingdom. Materials studied by the Poles for determination of their susceptibility or resistance to microbial attack include adhesives, leather, lubricants, paper, plastics, rubber (natural or synthetic), soaps, textiles, and wood.

Poland has an active well-balanced metallurgical research and development program. The metallurgical industry is a very important cog in the country's economy, and this is reflected in the breadth and scope of its metallurgical research. Although the bulk of the research is directed toward solving metals production problems, a significant effort is directed toward gaining a better understanding of materials behavior under various service conditions. The quality of Polish metallurgical research is excellent, especially their extensive work in applied areas, and the scope of the overall effort is about properly balanced between the applied and the basic or fundamental. A greater emphasis on fundamental research cannot be justified in a country of Poland's limited resources. Poland excels in research on corrosion and stress corrosion, foundry technology, and mechanical metallurgy. In overall quality and quantity, the program is above that in East Germany but below that in Czechoslovakia.

Poland has a long history as a metals producing area. A plentiful supply of coal combined with deposits of iron ore and certain nonferrous ores formed the basis of a metallurgical industry in the past and led

to the establishment of a steel and foundry industry. Carbon from the coal also led to the establishment of an alumina reduction industry. Poland also has deposits of copper and zinc ores, and these have formed the basis of the nonferrous metal industry.

Research on steels is carried out principally at the Institute for Ferrous Metallurgy in Gliwice, which works closely with steel mills in incorporating new developments into commercial practice, and the Academy of Mining and Metallurgy in Krakow. The former is the research institute for the Polish steel industry and directs its attention to improved methods in the refining and production of steel. Efforts include the preparation of iron ore for refining, blast furnace operations, vacuum melting and treatment, continuous casting, and metal working. The academy in Krakow, by contrast, concentrates its efforts on the physical metallurgy of steels and the development of improved steels. Dr. A. Krupkowski of this academy is an outstanding metal thermodynamicist and, with Dr. W. Truszkowski, has done excellent basic research on mechanical metallurgy. High-quality research in foundry technology is done at the Foundry Research Institute in Katowice. This institute ranks among the leaders in the Eastern European countries in foundry research. Recent efforts have included the study of various molding sands, foundry mechanization, and the development of improved casting alloys.

The Institute of Ferrous Metals in Gliwice has done extensive research on the refining of nonferrous metals and on the physical metallurgy of nonferrous metals. Excellent research on powder metalurgy has been done at the institute by Dr. W. Rutkowski, whose recent efforts have been in conjunction with the Institute of Nuclear Physics in Krakow on the dispersion strengthening of uranium with uranium oxide.

The corrosion of metals is studied at several facilities, but the most outstanding research on this subject has emanated from the Institute of Physical Chemistry in Warsaw. Dr. M. Smialowski has done extensive research on stress corrosion cracking and hydrogen stress cracking. He is a world-renowned expert in these two important technical areas and has lectured extensively throughout the United States. His wife, Dr. Z. Szklarska-Smialowska, also at this facility, has done excellent basic research on the corrosion of steels. She is known world-wide for her research on the pitting corrosion of stainless steels.

Excellent research on fracture mechanics, damage criteria, and fatigue has been done at the Institute for Fundamental Technical Problems (IPPT) in Warsaw. These efforts have been directed toward gaining a better understanding of failure criteria for metal components under various service conditions. This is an area of technology that involves both the metallurgists and the mechanical stress analysts. As part of this overall program, Dr. S. Pileski has done extensive basic research on dislocation movements and pile-ups during the fatigue loading of aluminum.

A modest amount of fundamental research is conducted at the technical universities. This effort has included the study of stacking faults, magnetic domains in thin films, high silicon electrical steels, and research on the oxidation of metals.

Research on welding is well covered at the Central Institute for Welding Technology in Gliwice. Relatively little research on nuclear metallurgy is conducted. Relatively little research on gas turbine superalloys, titanium, or refractory metals is undertaken in Poland; nickel, cobalt and titanium are not produced in Poland. The research effort is geared generally to the metals produced that are of importance to the nation's economy. Finally, virtually all research efforts are carried on in government laboratories or technical universities; practically no research is done in plant laboratories.

b. Physics and mathematics

Physics research in Poland, which has been growing significantly during the past few years, generally covers a limited number of subbranches that the Poles feel are important to their national economy. Nearly 50% of their physics research effort is devoted to solid state properties and materials development and improvement. Polish interest in magnetohydrodynamics, plasma physics, and laser technology has grown significantly during the past few years to the point where it absorbs about 14% of their basic physics effort and has become strongly interrelated. The trend toward nuclear sciences has leveled off and is diminishing substantially, with the exception of nuclear engineering. This is shown by the combined effort in both high- and low-energy nuclear research, falling slightly below 14% of the Polish effort. The Poles do have access to the experimental facilities of the Soviet Joint Institute for Nuclear Research at Dubna. The remaining effort in physics research, nearly equally divided, consists of: vacuum technology, gravitation and relativity, acoustics and shock vibration, and molecular and atomic structures.

Solid-state physics research during the past 3 or 4 years has been experiencing a tremendous growth at the various PAN institutes, institutes and laboratories of the schools of higher learning and technical universities, and the various academies of Poland. The

main areas of concentration have been in magnetic, semiconductor, and metallurgical materials. Most of the research is aimed at implementation of Poland's electronics and computer industries, with some involvement being directed toward steel manufacturing and processing. The Technical University of Wroclaw and the Semiconductor Institute of PAN appear to have the major portion of support in this work. Their activities consist of research into properties of ferromagnetic and antiferromagnetic materials, magnetic influences, thermodynamics of spin models, spin wave theories, relaxation, temperature effects on domain structures, thin permalloy tapes, piezomagnetic ferrites, disordered systems, and magnetic anisotropy. Good research is being done in studying spin wave theories associated with antiferromagnetism at the University of Wroclaw where phase transitions from antiferromagnetism at various low temperatures are being studied. Similar work is being done at the Technical University of Warsaw in connection with static spin pair correlation functions. The institutes of PAN have the major programs dealing with semiconductor properties, and the various universities in Warsaw and the Nicholas Copernicus University of Torun deal with investigations related to bulk materials. At the Institute of Electronics Technology, studies are underway with semiconductor devices of the conventional types, purely for the purpose of gaining information on operational mechanisms.

Computer-oriented electronic materials are being studied at Nicholas Copernicus University in connection with the switching phenomenon of amorphous carbon. The solid-state physicists aid other specialists who are active in metallurgical fields. At the Technical University of Warsaw, such activity is commonplace in studies related to powder metallurgy with objectives of improving materials used for relay contacts, aluminum-zinc alloys, and work associated with crack growth, corrosion, and creep. A modest series of programs is being expanded at the Technical University of Wroclaw in relation to photoelectric and photoconductive effects and behavior of several semiconductors. At PAN the research is concerned with effects of quenching and electric fields on photoconductivity, whereas, at the Wroclaw research laboratory, optical constants are being reviewed for certain types of thin films. Some work in optical spectroscopy is underway also at the Marine Engineering College on optical and infrared parameters.

Poland ranks high in its past development of lasers and their application to industry and metrology. At the present time, this expertise is being applied in studies of plasma heating and magnetohydrodynamics. An increased trend is shown for these studies at the institutes of PAN under the direction of one of Poland's foremost physicists, L. Kaliski. He is considered the leading authority on plasma heating and his latest works deal with the phenomenon of cumulation-laser heating of deuterium-tritium plasma to gain understandings on energy increase for attainment of critical temperatures. His group shows a good understanding of the subject concerning magnetic focusing and thermonuclear fusion processes. Another physicist, E. Infield, has a well established reputation throughout Europe in the magnetohydrodynamic work he is performing at the Institute of Nuclear Research, Warsaw. His work involves plasma confinement and successful establishment of equilibrium configurations, as well as other activities concerned with ball lightning.

Except for activities associated with nuclear engineering related to electrical power generation, research in the nuclear sciences has been declining. Most of the low-energy nuclear research has become applied in nature and is concerned with nuclear reactions and scattering and the mechanisms associated with them. The major portion of low-energy research takes place at the various nuclear research institutes located in Warsaw and Krakow, and in the Swierk/Otwock area. The activities at these institutes involve studies of the osmium isotope reactions with natural osmium at 14.8 MeV neutron energy, the development of dosimeters, and the process for the forming of lithium fluoride powders to study excited states of krypton and rubidium isotopes. At the Institute of Nuclear Research at Warsaw, nuclear specialists are studying the gamma ray spectra from the indium isotope reaction at various neutron energy levels by means of inelastic scattering. At the University of Warsaw, research is underway that deals with deuterium-tritium reactions with rare-earth nuclei from both a theoretical and experimental standpoint. Since the Poles collaborate with others at the large accelerator laboratories (Dubna and Serpukhov in the U.S.S.R. and CERN at Geneva) in experimental high-energy nuclear physics, they have become active and well respected in their relations with international teams. In Poland the subjects of special interest include hypernuclear physics and strong reactions. Several Polish theoretical physicists are researching high-energy problems; among them is J. Werle, who is well known for his work on phenomenological theories of strong reactions. Centers at Krakow and Warsaw pursue research in high-energy and elementary particle physics which has evolved

from cosmic ray work undertaken at both centers. A considerable amount of cosmic ray physics is still carried out at Lodz. At Nuclear Institutes of Warsaw and Krakow, studies are being conducted dealing with hadron interactions and the development of models for hyperon-nucleon reactions. At the Jagiellonian University in Krakow, physicists are engaged in studying hyperon polarizations resulting from meson-baryon reactions. At the same university, others are probing theories involved with hadron scattering associated with the model for diffractive production of particles in high-energy collisions.

The Poles have been hampered in various subbranches of physics research that require the use of vacuum technology, primarily because they lack the necessary equipment. To overcome this deficiency, efforts are being made to produce their own high-vacuum machinery. Such developments occur at the Institute of Electronics Technology where work is underway on studies of characteristics for orbiton ion-getter pumps, zeolite traps, evaporators, diffusion pumps, seals, and instrumentation. Although Poland ranks high in mathematics, there is little activity in research on gravitation and relativity. Probably the best specialist in Poland on relativity is Dr. B. Kuchowicz at the University of Warsaw. His work involves searches for exact solutions of gravitational field equations that relate to the general relativistic treatment of stellar structures. In acoustics, ultrasonics, vibration, and shock waves, Poland's programs are relatively modest. Most of the research is applied and is being done at PAN institutes and various university laboratories. Probably the most advanced work is that being done by J. K. Zienuk in his experiments dealing with ultrasonic holography at a PAN institute in Warsaw. Other important work is concerned with velocities and polarization of elastic waves propagating in cubic crystals. This research is done by J. Mielnicki, also at a PAN institute in Warsaw. To be successful in such research, experimental work requires nearly perfect crystals. Shock and vibration research in Poland is related to aerodynamics and some of it involves the propagational problem of plane shock waves in plastic bodies that possess elastic unloading properties. Research in sonics is good. The Polish work involves characteristics of sound, tone, and directivity, with possible applications to musical instruments.

The most advanced Polish research in molecular and atomic physics occurs at the Nicholas Copernicus University where investigators are studying electronic structures and the spectra of organic molecules. Also, some research there involves the study of hyperfine splitting of radical ions in the electron-spin resonance spectra. Others at the University of Warsaw are studying interaction energies of ground state hydrogen atoms

Among the Communist countries, Poland probably is second only to the U.S.S.R. in amount of attention given to mathematical research, although it is closely rivaled by the much less populous Hungary. Poland has a long and commendable history of performing mathematical research, although political difficulties have intervened at times. All of the main fields are investigated actively by Polish mathematicians, who are recognized internationally as competent. Dr. Kazimierz Kuratowski of PAN is the leading Polish mathematician and one of the most outstanding in the world. In their present circumstances, the Poles are producing new mathematics at a good rate, but its form seems subject to some political influence. Thus they tend toward applicable forms of mathematics but lack the computing capacity that many applications of mathematics require.

It is estimated that between 1% and 2% of the world's mathematical research is done in Poland. Subject areas strongly represented in this research are analysis (especially differential and functional equations and function analysis), logic, and topology. Also well represented are geometry, mathematical physics, and subjects related to economics and statistics. Algebra is represented somewhat weakly but, on the whole, the Polish effort may be considered fairly well balanced. It is interesting also that much foreign mathematical research is published in Poland, with a large share coming from the United States, with the Soviet Union well represented, and with contributions from many other widely scattered countries. Polish journals seem to offer an international forum, a situation probably fostered by periodic use of Poland for international symposia. The Poles also publish their work abroad moderately often, distributing it to many countries.

Fairly sophisticated applications of mathematics to military and industrial decisionmaking are being made in Poland. These applications draw on the principles of operations research and the capabilities of computer and data transmission hardware to produce systems which serve as decisionmaking aids. Systems are currently in use on an experimental or limited operation basis, and plans call for integration into large-scale systems. The technology itself is several years behind that of the United States and of the Soviet Union, but the Poles are making good use of the available technology and knowledge to develop these systems.

Poland's mathematical standing in Eastern Europe should profit soon from the establishment of a new international mathematical training center for advanced training of scientific personnel. The new Stefan Bantach Center is to begin work in 1973 with its seat at the Institute of Mathematics of the PAN, Warsaw. With this center, the academies of Bulgaria, Czechoslovakia, East Germany, Poland, Romania, Hungary, and the Soviet Union will contribute to tasks established in the CEMA program, and the center will also conduct common research and promote exchange of information.

c. Astrogeophysical sciences

(1) *Astronomy and space sciences*—Theoretical, primarily stellar, astronomy in Poland is of high quality. One of the greatest strengths is in the classical fields of theoretical and observational astronomy. The Poles are noted for their work on eclipsing binaries and stellar evolution. Optical observational astronomy is limited by the climate and by the general inadequacy of equipment. Considerable astronomical scientific exchange occurs between Poland and the West, particularly France and the United States.

The Warsaw Astronomical Center for theoretical astronomy is a joint effort of the Institute of Astronomy, Warsaw, of PAN, and of the Astronomical Observatory of the University of Warsaw. Other principal astronomical observatories in Poland are located at the Jagiellonian University, Krakow, recognized center for the study of eclipsing binaries; the Adam Mickiewicz University, Poznan; the Nicholas Copernicus University, Torun; and the University of Wroclaw. The observatory at Poznan operates a latitude station for PAN at Borowiec, important for its cooperative program, and a similar station at Irkutsk, U.S.S.R., located 90° to the east on the same parallel. The observatory at Torun is the recognized center for observational astronomy in Poland and was to have been equipped with a 2-m reflector. This project, however, was canceled in December 1969 after the mirror blank had been cast by the Zeiss Jena Company of East Germany. It is also the principal center for radio astronomy and is equipped with several interferometers, primarily for solar observing. An array for long baseline interferometry is under construction. An average size 60-cm optical reflector is being constructed by Zeiss Jena for installation in 1973 at Grojec, near Warsaw, and efforts are underway to improve the present inadequate computer facilities that are available to Polish astronomers.

Polish astronomical research has continued to emphasize the study of binaries and stellar evolution. Other activity has been primarily solar research, although some lunar, meteor, and cometary astronomical studies have been made. Some space biological and space medical research has been conducted, but generally space research, coordinated by the Committee on Investigation and Peaceful Uses of Outer Space, PAN, is limited principally to ground-based activities. Polish space activity is limited primarily to satellite tracking, and an optical tracking network provides data for the computation of satellite ephemerides and for utilization in geodetic research. Certain stations in the network participate in the Soviet-sponsored INTEROBS and in the French-coordinated EUROBS programs for the study of upper atmospheric density. Besides developing the Meteor series rockets, Poland has designed and produced equipment for use in Soviet-launched geophysical vertical probes. This equipment consists of X-ray spectroheliographs and a system of X-ray pinhole cameras. Poland also participated with other Communist Bloc countries and the U.S.S.R. in designing the scientific payload for Interkosmos 6. This payload consisted of emulsion plates to register very high energy cosmic rays and was returned to earth after 4 days for analysis of the data.

The Institute of Nuclear Physics, Krakow, has made very high-energy cosmic ray observations from balloons. In 1971 the Institute was collaborating with Moscow State University in preparing a similar experiment to be satellite-borne. PAN's Institute of Geophysics, at Warsaw, has a cosmic ray observatory at Belsk Duzy. Recent observational research in Poland has emphasized the study of the characteristics of and problems involved in the observation of cosmic ray air showers. The Industrial Telecommunications Institute, Warsaw, has had an ionospheric sounding station: only a small amount of ground-based ionospheric research is conducted in Poland.

(2) *Meteorology*—The Poles have an active meteorological research program of good quality. The program is broad in scope, including actinometry, aerology, atmospheric chemistry and diffusion, cloud physics, and synoptic meteorology. The Institute for Hydrometeorology and Water Economy, created in March 1973 within the Ministry of Agriculture, controls the national weather service—formerly the autonomous State Institute of Hydrology and Meteorology—which conducts much of the research, but some work is done in the universities and by PAN's Institute of Geophysics at Warsaw. Outstanding work in atmospheric electricity has been done in Poland.

Research is conducted also in climatology and physical and synoptic meteorology. There is a meteorological radar installation near Warsaw. The limited amount of weather modification research is directed primarily to fog dispersal and hail suppression. For the latter purpose a small rocket, the Taski-2, having a ceiling of about 3 kilometers (km.), has been developed for seeding hail clouds.

The most noteworthy meteorological research effort is the sounding rocket program, centered at the Rocket and Satellite Research Department, Krakow. The principal vehicle has been the Meteor-1, a single-stage, solid-fueled rocket having a ceiling approaching 40 km. Chaff is released at predetermined heights to permit the radar tracking of stratospheric winds. From 1965 through 1969, about 200 of these rockets were launched from Krakow and from Ustka, near the Baltic coast. More advanced rockets capable of reaching 60 km. or more are becoming available. These are the Meteor-2, which lofts a drop sonde to measure pressure and temperature, and the Meteor-3, a two-stage, solid-fueled replacement for the Meteor-1. The Rocket and Satellite Research Department is also the site of Poland's only automatic picture transmission (APT) meteorological satellite data receiving station. To date, this facility has been used only to receive data from Soviet satellites when the Soviet APT program becomes operational.

(3) *Terrestrial geophysics and geology*—Terrestrial geophysical and geological research in Poland is competent but not significant internationally. The key organization in geophysics is the PAN's Institute of Geophysics at Warsaw, which has six geophysical observatories, variously equipped to make geomagnetic, seismic, or telluric current observations. One observatory, at Hel, conducts full time geomagnetic observations, while others make intermittent measurements. There is also a 21-station network in Poland to observe geomagnetic secular variations. The small amount of recent Polish theoretical geomagnetic research has included a study of the origin of the geomagnetic field. Microseismic, standard, and deep seismic observations are made. Routine work includes the determination of earthquake epicenters, magnitudes, and mechanisms, and Poland is cooperating with Czechoslovakia, Romania, and the U.S.S.R. in a study of the Mohorovicic discontinuity.

The emphasis in geology is upon mineral prospecting, using both geophysical and geological techniques. Activity is directed by a Central Bureau of Geology, which is on the ministerial level. The bureau has subordinate to it various regional entities, for example, the Institute of Geology, Warsaw, which is analogous to a national geological survey, as well as other organizations. In 1968, an agreement was reached by Poland and the U.S.S.R. for cooperation in geophysics and geology, directed primarily to mineral prospecting along the Polish-Soviet border. Some scientific geological research is conducted in the universities and by the Research Center for Geological Sciences, Warsaw, of PAN.

(4) *Geodesy*—The Chief Geodetic and Cartographic Administration, Warsaw, conducts long-range technological and scientific research in geodesy and cartography in addition to further development and improvement of geodetic control networks. The above administration is directly subordinate to the Ministry of Internal Affairs, and coordinates project assignments levied from the committees of the Council of Ministers. The military organization for geodetic and cartographic research and mapping programs is headed by the Ministry of National Defense, and subordinate to it are the Polish Military Topographic Service, the Military Cartographic Works, and WAT. Polish scientists maintain active contact with scientists throughout the world through participation in international programs and conferences. Poland is an active member of the International Council of Scientific Unions and its Committee on Space Research, among other international organizations. Within Warsaw Pact countries, Poland encourages close scientific ties under the auspices of the Council of Economic Mutual Assistance (CEMA) and through the respective academies of science. Poland is an active participant in the general assembly conducted periodically by the International Union of Geodesy and Geophysics and was represented by very competent scientists at the XV General Assembly held in Moscow in 1971.

The planning for 1971-75 outlines the importance of continuity in the following fields: a) research in earth revolution, connected with participation in the international time, latitude, and longitude service; b) study of the earth's crust movements, tides, and mean sea level; c) chronological study of gravity changes with the use of satellite triangulation; d) gravimetric observation, especially in the Baltic area; e) study of atmospheric influences in observations and measurements; f) search for new methods in basic geodetic surveys; g) development of automated systems for geodetic data transformation; h) photogrammetry; and i) development of a most suitable scale and format for maps compiled by automated data bank procedures.

The country is covered with a new astrogeodetic net of 181 first-order triangulation points, providing a

base for second-order fill nets and for lower order networks covering the whole country with at least one triangulation point for every square, 16 kilometers on each side. The national network, tied to the Polish reference datum point Borowa Gora, was adjusted and computed in the unified Soviet "System of 1942" and tied in with the networks of neighboring countries. A very well planned and dense net of Laplace points puts the Polish astrogeodetic network on the internationally acclaimed high standards of accuracy.

In the international project of determining the shape of the geoid, the Institute of Geodesy and Cartography (IGiK) and PAN continue the work of astrogeodetic leveling. A map of deflections of the vertical, with graphically represented components, was compiled at the scale of 1:2,000,000. In the field of geodetic astronomy, scientific work is directed by the IGiK, with collaborative support from PAN's Astronomic Station at Borowiec, near Poznan, the IGiK Astrogeodetic Station at Borowa Gora, and the Astrogeodetic Station, Jozefoslaw, of the Warsaw Polytechnical Institute. The fundamental astrogeodetic point, Borowa Gora, is tied to the fundamental points of Bulgaria, Czechoslovakia, East Germany, Hungary, Romania, and the U.S.S.R. All the stations participate in the time service program, and Borowiec and Jozefoslaw are also latitude stations. The results of observations are sent to *Bureau International de l'Heure* (BIH) in Paris, to International Polar Motion Service (IPMS) in Mizusawa, Japan, and to the U.S.S.R. Scientific Research Institute for Physical and Radiotechnical Measurements in Moscow; the results are published also in the bulletins of the stations.

In satellite geodesy, observations of artificial satellites have been a part of astrogeodetic work since 1957. The Geodetic Committee of PAN plans and coordinates scientific research on a national scale to be carried out by the IGiK and other research institutions. Currently, six observation stations in Poland are part of the international system COSPAR and cooperate with the Pulkovo Observatory (a section of Leningrad), U.S.S.R., which is the coordinating station for artificial satellite observations.

The East European Sub-Commission for Satellite Geodesy coordinates geodetic studies based on optical tracking data of satellites obtained through the multilateral cooperation of the Academies of Sciences of the Warsaw Pact countries. In 1969, this Sub-Commission was included in the Working Group on Cosmic Physics for international cooperation among socialist countries, called Interkosmos. The results of scientific research on satellite geodesy as well as on geophysical problems solved on the basis of satellite trackings data are published in annual issues of the international volume *Observations of Artificial Satellites*. The Poznan station is equipped with the PO-2 camera which was designed and built in Poland.

International satellite tracking programs during the 1970-75 period in which Poland is an active participant include the following:

The Riga-Sofia Program, which is based on 1968 observations of the Echo-2 satellite.

The Dynamics Program, which anticipates photographic observations of faint satellites by dynamical methods, based on numerous observations for a long time. The satellites to be observed are Midas-4, Geos-A, and Geos-B.

The Arctic-Antarctic Traverse Program (also known as The Big Arc Program, a Soviet conception), an extensive program of combined photographic angle measurements of this traverse, involving seven tracking stations positioned over the 12,500-kilometer arc from Spitzbergen (Svalbard) to Mirnyy (a Soviet station in Antarctica).

The International Satellite Geodesy Experiment (ISAGEX), which is intended to provide more information on the gravitational field of the earth. The program was proposed by the French *Centre National d'Etudes Spatiales* in the framework of COSPAR. Satellites to be observed are Peole, Geos-1, Geos-2, D1-C, D1-D, BE-B, and BE-C, all equipped with laser reflectors.

The EXGEOS, a cooperative program between West and East European Sub-Commissions for Satellite Geodesy with a goal of establishing an ideal satellite triangulation network to cover Europe. Satellites to be observed are Geos-A, Geos-B, Explorer-19, and Explorer-39.

Among Warsaw Pact countries, Poland ranks second to the U.S.S.R. in the development of computerized techniques. Studies and research on new methods of automated adjustment computation continue at IGiK, at the Warsaw Polytechnical Institute, and the Krakow Academy of Mining and Metallurgy. The leading facilities for the development and production of digital computers are the Institute of Mathematical Machines in Warsaw and the Wroclaw Electronic Plant (ELWRO).

During the 1971-75 time frame, Polish economic planners anticipate an overall production of 500 computers, mainly domestic models R-30, ODRA-1305 (medium capacity), ODRA-1304, -1204, -1205 (small capacity), and K-202, ODRA-1325 (minicomputers). According to current statistics, 10% of computer equipment would be allotted to geodetic-

cartographic computerized operations. A complex project, identified under the newly adopted name of Geodetic-Cartographic Informatics, is in preliminary planning stages. Technically, this project envisions automation in the field of mapping to combine geodetic, cartographic, gravimetric, and stereophotogrammetric background material into a centralized data bank.

(5) *Hydrology, hydraulics, and coastal engineering research*—Poland is one of the leading East European countries in hydrologic and hydraulic research. Most research is directed toward a more thorough utilization of water resources for irrigation, navigation, flood control and river regulation, power, and water supplies. Recent efforts funded by the United Nations Education, Scientific, and Cultural Organization (UNESCO) deal chiefly with test models and field investigations for optimum development of the Vistula river basin. Polish hydrologic institutes are becoming increasingly aware of the need for effective pollution control and of managing biochemical, industrial, and nuclear wastes. Continuing research is being conducted to improve the design of various hydraulic structures and to devise new hydraulic components and instrumentation. Numerous tests have been conducted with the aid of wind tunnels in studying the phenomena of fluid mechanics in hydraulic structures.

Poland is one of the leading Warsaw Pact countries in coastal research. In recent years coastal research has concentrated on marine dynamics, shore processes, and shore protective works. Research is done in forecasting coastline changes, wave dynamics, delta sedimentation, migration and stabilization of coastal dunes, coastal shoreline processes and movement of particles in the littoral zone, and various problems of harbor and basin sedimentation. Polish scientists participate in several international organizations relating to coastal engineering problems and also work closely with their counterparts in East Germany and the U.S.S.R.

(6) *Oceanography*—The marine sciences have increased in importance in Polish scientific circles, although they are not first in its research efforts. Polish oceanographic capability ranks about the same as Denmark and East Germany. Applied research is receiving much greater emphasis than basic research. Oceanography appears to be the research arm of the maritime economy rather than a scientific discipline in itself. Polish marine science facilities are subordinated primarily to ministerial agencies and to a lesser degree to the Polish Academy of Sciences, because the ministerial agencies, especially the Ministry of Transportation, Ministry of National Defense, and the Ministry of Education and Training, have more funds for research in the marine sciences than organizations associated with PAN. In general, although funds for research are limited, Polish oceanographers do excellent and reliable work. A Special Committee on Oceanographic Research (SCOR) was established in 1961 (still active to date) under PAN to coordinate marine science activities and give direction in the expenditure of the academy's funds for oceanographic research.

Poland's marine economy is highly developed and is an increasingly important component of the economy. Polish oceanographic research is directed toward biological oceanography investigations for the development of marine fisheries and toward forecasting of the coastal environment such as tidal predictions, ice, and weather. In coastal work, considerable effort is given to sediment transport in the littoral zone, wave effects on beaches, shoreline processes, harbor engineering, and sand dune migration. In addition, Polish oceanographers are concentrating on the monitoring of radioactivity in the sea and air, geomorphology and geology of the Baltic Sea, use of radioisotopes as tracers, and the study of wave dynamics.

Poland is strong in biological and geological oceanography and weak in physical oceanography, although activity in the latter appears to be increasing. This accelerated pace is noticeable in underwater sound propagation studies and sea level changes.

Most of the oceanographic instruments and equipment used by Polish oceanographers is of foreign manufacture, primarily from the U.S.S.R., Great Britain, France, West Germany, and the United States. Some of the indigenously made devices include oceanographic winches, underwater television, and an echo sounder for use with fishing nets. In addition, Polish oceanographers designed and constructed a series of underwater habitats. *Medusa I*, which was the first undersea habitat put into operation by Poland, was tested in 1967. *Medusa II*, a modification, underwent trials in 1968. *Medusa III*, a larger version of *Medusa II*, was deployed in the Gulf of Danzig at a 60-meter depth for 2 weeks during the summer of 1970.

The most important Polish oceanographic organizations are the Research Center for Oceanography, under the State Institute of Hydrology and Meteorology; Marine Fisheries Institute, subordinate to the Ministry of Transportation; and the Hydrographic Office of the Navy, all located in

Gdynia; Institute of Hydroengineering and the Maritime Institute, both at Gdansk; and the Marine Station at Sopot. The Marine Fisheries Institute has just acquired the 293-foot research ship *Professor Siedlecki*, which displaces 3,650 tons and has numerous laboratories. It is expected to be put in service in early 1973 and is designed to operate in the North Sea and the North and South Atlantic Oceans. The Institute also operates five other small research ships.

The Department of Fisheries, established in 1951 at the Higher School of Agriculture, is still operating and trains personnel in a 5-year program that includes oceanography.

Attendance of Polish oceanographers at most international meetings has been rather poor; however, Poland is a member of several important international oceanographic organizations such as the Intergovernmental Oceanographic Commission (IOC), International Council for the Exploration of the Sea (ICES), and the Conference of Baltic Oceanographers. Poland cooperates closely with East European Communist countries in scientific exchange programs and joint oceanographic surveys. Poland joined the U.S.S.R., East Germany, Finland, and Sweden in oceanographic investigations in the Baltic Sea during 1969 and early 1970. Research included measurements of temperature, salinity, nutrient content, oxygen, hydrogen ion concentration, and alkalinity. This program, designated the Baltic Sea Year, was proposed by Sweden at the 6th Conference of Baltic Oceanographers held at Sopot.

Glossary (u/ou)

ABBREVIATION	FOREIGN	ENGLISH
IBJ	*Instytut Badan Jadrowych*	Institute of Nuclear Research
IFJ	*Instytut Fizyki Jadrowej*	Institute of Nuclear Physics
IGiK	*Instytut Geodezji i Kartografii*	Institute of Geodesy and Cartography
IPPT	*Instytut Podstawowych Problemow Tcehniki*	Institute for Fundamental Technical Problems
KNiT	*Komitet Nauki i Techniki*	Committee for Science and Technology
PAN	*Polska Academia Nauk*	Polish Academy of Sciences
WAT	*Wojskowa Akademia Techniczna imienia Generala Jaroslawa Dabrowskiego*	General Jaroslawa Dabrowski Military Technical Academy
ZETO	*Zaklady elektronioznej Techniki Obliczeniowej*	Organization of Electronic Technical Computers

Places and features referred to in this chapter (u/ou)

	COORDINATES	
	° ′N.	° ′E.
Belsk Duży	51 50	20 49
Blachownia Śląska	50 22	18 17
Borowa Góra	52 29	21 02
Borowiec	52 17	17 02
Bronowice	50 06	19 53
Bydgoszcz	53 09	18 00
Danzig, Gulf of (*gulf*)	54 40	19 15
Gdańsk	54 21	18 40
Gdynia	54 30	18 33
Gliwice	50 17	18 40
Grójec	51 52	20 52
Hel	54 37	18 47
Józefosław	52 06	21 02
Katowice	50 16	19 01
Kraków	50 05	19 55
Łódź	51 45	19 28
Okęcie	52 11	20 57
Otwock	52 08	21 19
Płock	52 33	19 42
Polkowice	51 30	16 04
Poznań	52 25	16 58
Pulawy	51 25	21 58
Służewiec	52 10	21 00
Sopot	54 27	18 34
Świerk	52 07	21 21
Szczecin (Stettin)	53 25	14 35
Toruń	53 02	18 36
Ustka	54 35	16 51
Warsaw	52 15	21 00
Wrocław (Breslau)	51 06	17 02
Żarnowieckie, Jezioro (*lake*)	54 46	18 04
Żerań (*sec of Warsaw*)	52 18	20 59