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May 1974

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NATIONAL INTELLIGENCE SURVEY

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This chapter was prepared for the NIS by the Central Intelligence Agency. It includes contributions by the Defense Intelligence Agency and the Departments of the Air Force, Army, and Navy. Research was substantially completed by November 1973.

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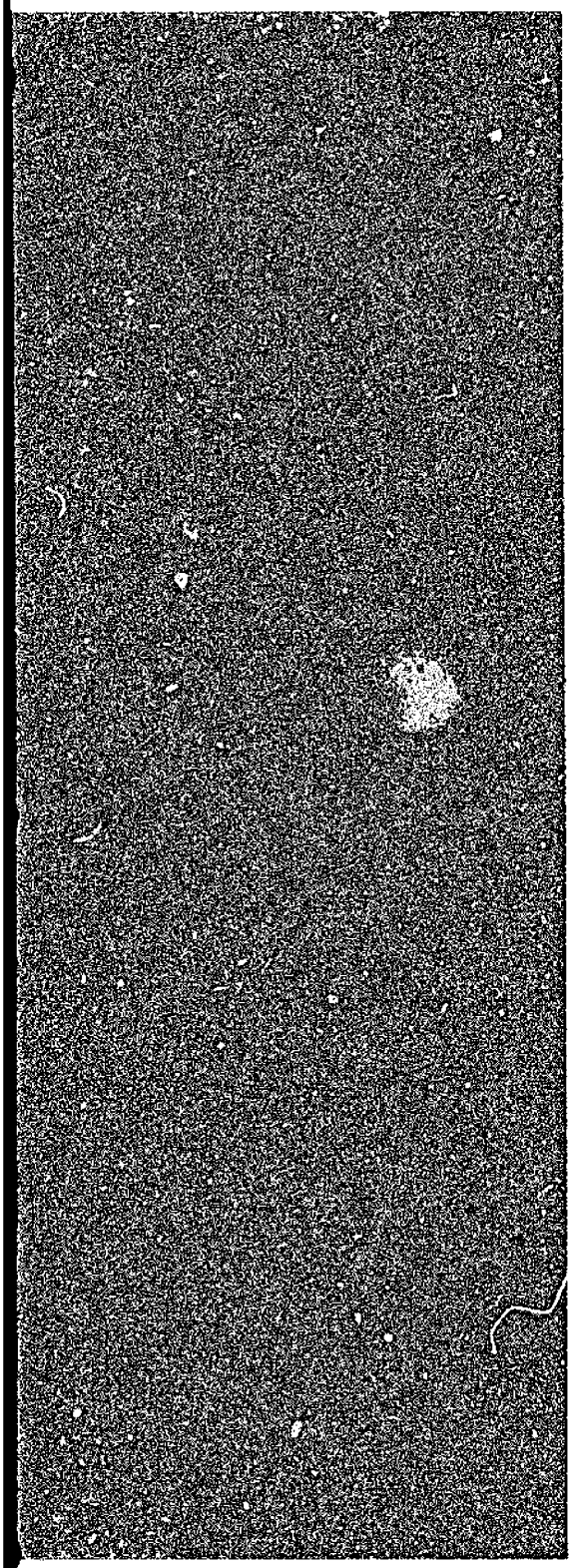

Czechoslovakia

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This chapter supersedes the scientific coverage in the General Survey dated December 1971.

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Science

A. General (S)

Czechoslovakia occupies a leading position in scientific accomplishments among the East European Communist countries. The Czechoslovaks are capable of doing good scientific research, although the total volume is probably less than 10% of that done in the U.S.S.R. Progress in scientific research and development has been favored by a strong scientific tradition, a high level of literacy, a good educational system that places emphasis on science and technology, and one of the highest standards of living among the East European countries. The Czechoslovak scientific tradition, extending back to the early part of the 17th century, is based on the work of such scientists as the German-born astronomer, Johann Kepler, and the Danish astronomer, Tycho Brache, who did much of their work in Prague during 1600-10; Jan Marek, discoverer of the dispersion of white light by a prism, who worked at Charles University in Prague around 1620; Jan Ev. Purkyne, an outstanding Prague physiologist, who studied physiological optics; and Gregor Mendel, Moraviani "Father of Genetics." More recently, Czechoslovakia has developed several outstanding scientists, including Jaroslav Heyrovsky, who received the Nobel prize in 1959 for his discovery and development of polarography.

Scientific progress, although basically strong, has been affected adversely by foreign interventions and by internal political factors. During the period of German occupation prior to and during World War II and in the chaotic period following that war, the Czechoslovak research program declined substantially because of casualties, defections, and purges. After the Communists seized power in 1948, emphasis was placed on the development of heavy industry and on supporting fields of engineering and applied research. With the gradual relaxation of orthodox Communist leadership during the early and mid-1960's, Czechoslovak scientists obtained increasing freedom in conducting research. Liberalization continued during the first half of 1968 under the leadership of Alexander Dubcek. This situation changed abruptly in August 1968 with the invasion of Czechoslovakia by the other Warsaw Pact countries. Since the invasion, the Soviets have forced Czechoslovakia to revert to a more repressive regime, including strict censorship, increased bureaucratic controls, restrictions on travel, and purges of liberal scientists. Because the Czechoslovak Academy of Sciences (CSAV) and many individual scientists and professors strongly supported the liberalization policy and freedom of expression and discussion in scientific publications, the academic and scientific communities have been targets of repressive measures.

There has been a far-reaching purge of scientific leadership since 1968. Approximately 50 of the 65 directors of institutes of the CSAV have been removed from positions of management, either by assignment to nonsupervisory positions or by complete separation from their institutes. Replacements have been selected primarily on the basis of political reliability rather than scientific and technical capabilities, and Communist Party members are appointed to all leading positions. The academic community has been affected also. Qualified faculty members have been discharged for political reasons, and revised political criteria have been used for accepting students for university study. Under a new law, officers of the Academies of Sciences are appointed by the political authorities rather than being elected by the members. Also, appointments of academicians have been reduced from lifetime to 4 years. Presumably reappointment will depend on willingness to follow party lines.

Scientists and students of science frequently complain because, although some are permitted to continue their research, they cannot travel and are restricted from gaining access to many outside books and periodicals. Also they are unable to get technical and scientific information from the United States because they have no funds to renew subscriptions to leading journals. Instead, they are required to use the Soviet-operated scientific literature dissemination services that provide foreign papers and abstracts. Generally, the Soviet documentation services provide untranslated English articles, and translation of these involves lengthy periods of time. Representatives of

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the CSAV who are permitted travel to foreign countries are carefully screened and selected according to their party loyalty. In November 1971 the status of science was reported as extremely low because of purges so that there was a pronounced stagnation of activities at most institutes and university research centers. The federal Minister of Education was eliminated and some liberalization occurred. In late 1972, however, the government was continuing to exert pressure on the scientific community to increase cooperation with their Soviet counterparts and to refrain from contacts with Western scientists. Great emphasis was placed on maintaining good relations with party officials since it was made clear that the party would not tolerate neutral and liberal scientists in the country.

Scientific and technical activity has been seriously disrupted by the above repressions and changes. The present government has cut back drastically on scientific research funding and has redirected much of the effort into applied fields. As a result of currency restrictions, it is also almost impossible for the scientists to purchase Western equipment and supplies. However, the most drastic changes have been at administrative levels, and the large body of scientists and engineers is continuing to conduct significant research. Basic research in medical sciences is continuing. In most branches of science, however, the research effort is being directed mainly into those areas which contribute to the country's economic or military strength. Although many competent scientists and engineers have left Czechoslovakia since the 1968 invasion, the country has many capable young scientists and engineers to replace those who have left.

Czechoslovakia has attempted to maintain scientific contacts with both Communist and Western countries. Since August 1968, the Soviets have insisted that Czechoslovakia strengthen its scientific ties with the U.S.S.R. and other Communist countries. There has been extensive scientific-technological cooperation between Czechoslovakia and the U.S.S.R. Several thousand Czechoslovaks have visited the Soviet Union to study research and development methods and production technology. As of July 1971, it was reported that about 200 Czechoslovak organizations and about 200 Soviet organizations were engaged in a corresponding number of joint scientific research and development projects. However, at the working level there has reportedly been considerable animosity between scientists from the two countries, notably at the U.S.S.R.'s nuclear research facility at Serpukhov. Czechoslovakia has signed bilateral agreements with other Communist countries and with some Western countries for exchanges of personnel, information, and materials. In June 1972 a contract was signed between petrochemical enterprises in Czechoslovakia and East Germany calling for economic, scientific, and technical cooperation in the production and exploitation of unsaturated hydrocarbons.

During the past 10 years, scientific and technological relations have expanded considerably between Sweden and Czechoslovakia. Cooperation has been effected through agreements between scientific and engineering academies and between governments. As a result, Czechoslovak scientists have participated actively for periods of a year or more in special projects at various Swedish institutes. A bilateral agreement between the two governments was signed in October 1971. One of its objectives was to strengthen scientific and technical cooperation.

Czechoslovakia belongs to many organizations of the International Council of Scientific Unions and has participated in their worldwide cooperative programs. It is a member of such international scientific bodies as the International Union of Geology and Geophysics (IUGG), the International Union of Biological Sciences, the International Unions of Pure and Applied Chemistry and Physics, the International Union of Food Science and Technology, and the International Astronomical Union. Czechoslovakia participates also in various U.N. agencies such as the U.N. Educational, Scientific and Cultural Organization (UNESCO), the World Health Organization (WHO), the World Meteorological Organization (WMO), and the International Atomic Energy Agency (IAEA).

Czechoslovakia has in the past provided facilities for international scientific meetings: for example, the Prague Symposium on Macromolecular Chemistry attracted scientists from 27 countries and the International Union of Biological Sciences held its 15th Congress in Prague. In 1966 the World Congress of Archaeology held its sessions in Prague. Over 300 scientists attended a 5-day symposium on geophysics in October 1972.

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

Scientific research and development are controlled and administered primarily by the federal government, which in turn is under the control of the Czechoslovak Communist Party. Since January 1969 the government has reorganized its ministries, abolishing most of the ministries which existed prior to that time, and has strengthened its control over the

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CSAV. The real authority in most of the scientific research facilities is held by the local Communist Party cell. Under the new government organization, the two provincial or republic governments—the Czech Socialist Republic and the Slovak Socialist Republic—have established their own separate ministries in some fields. In some cases, the activities of these provincial ministries are coordinated by new federal ministries. The federal government, however, does not have a ministry for education nor a ministry for health, since these areas are considered to be the responsibilities of the two states. The higher educational institutions and their affiliated research institutes are under the supervision of the state governments. The bureaucratic complexities of the present system of parallel federal and state ministries have caused serious difficulties in the administration of scientific research and development.

Federal ministries concerned with scientific activities include the Ministry of National Defense, Ministry for Technological and Investment Development, Ministry of Fuel and Power, Ministry of Agriculture and Food, Ministry of Posts and Telecommunications, Ministry of Transportation, and Ministry of Metallurgy and Engineering (Figure 1). Particularly important is the Ministry for Technological and Investment Development, which was formed in January 1971 from the Committee for Technological and Investment Development. This ministry controls all federal scientific and technical activities, including allocation of funds for the CSAV. Its minister, Ladislav Supka, formerly headed the Central Committee Department for Scientific, Educational, and Cultural Affairs. The Ministry for Technological and Investment Development is responsible for establishing a unified government scientific and technological policy and for coordinating and controlling scientific programs and certain development programs. The ministry formulates the applied research and development program with assistance

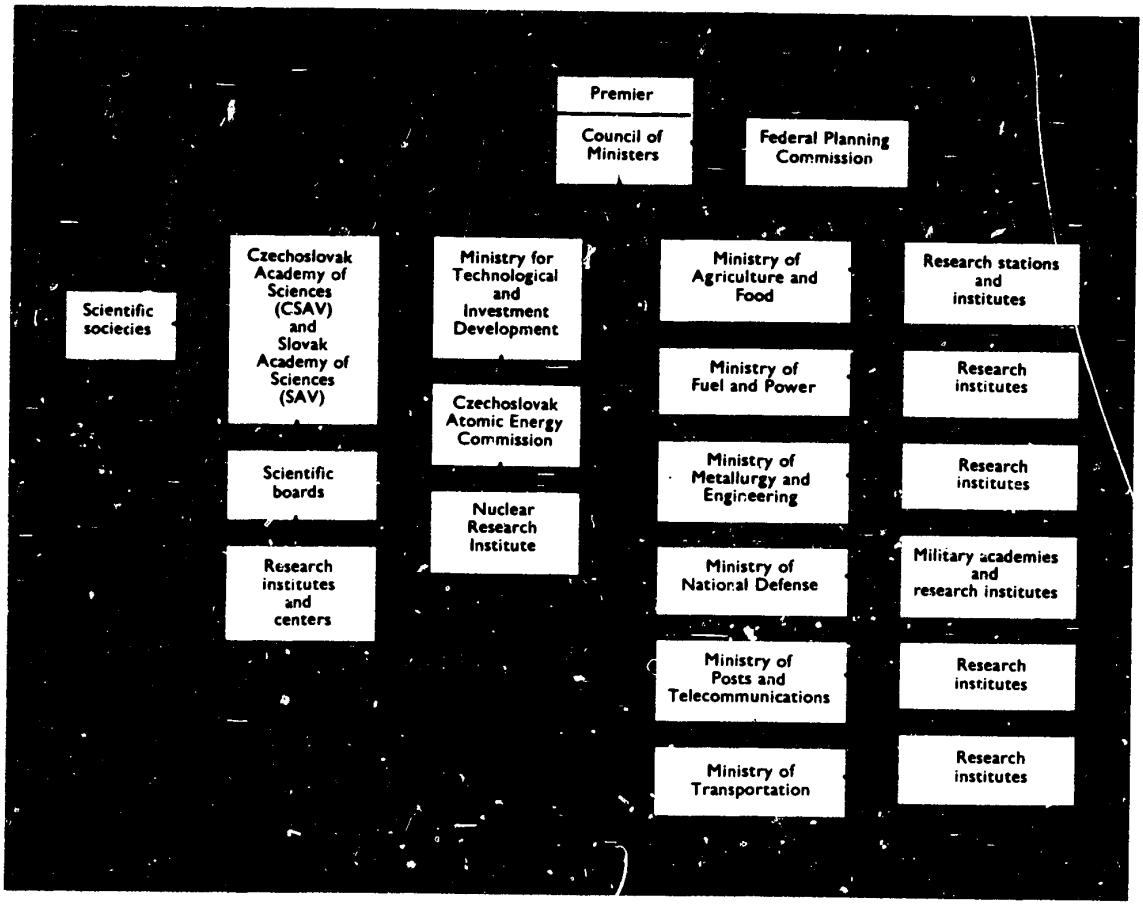

FIGURE 1. Federal government organization of scientific research and development (C)

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from the CSAV, while the CSAV is responsible for the basic research program, subject to approval of the ministry. This ministry is also responsible for supervising international cooperation in science and technology and has jurisdiction over the Czechoslovak Atomic Energy Commission. The latter is responsible for the peaceful utilization of atomic energy and for coordinating the nuclear energy program. However, nuclear powerplant construction is the responsibility of the Ministry of Fuel and Power. Formerly the commission was not directly involved in the operation of research and development facilities for nuclear research, which were under the CSAV, but recently, the Nuclear Research Institute at Rez (near Prague) has been placed under the commission.

The CSAV, created in 1952, was formerly a very powerful organization for scientific planning and coordination of research and for carrying out fundamental and applied research. In 1969 the new government took away much of the autonomy of the CSAV. The previously unimportant Slovak Academy of Sciences (SAV), which functions as a branch of the CSAV, was upgraded, thus ending the ability of the CSAV to speak for the entire scientific community in opposition to the new regime's policies. Many research facilities of the academies have been reorganized or abolished in order to strengthen government control and to insure leadership by Communist Party members. The regime controls the monetary and physical resources needed for scientific and technical activities and uses them to gain its objectives.

The academies continue to play an important role in scientific education and research through the approximately 130 institutes, laboratories, centers, and other facilities that operate under the control of various scientific boards of the academies. They cover such disciplines as biology, mathematics, physics, nuclear research, technical cybernetics and electronics, materials research, medical science, organic chemistry and biochemistry, chemical process fundamentals, and the astrogeophysical sciences. More than 30 formerly independent scientific societies have been placed under the framework of the CSAV. This grouping under one organization has promoted better cooperation and communication among the societies.

Since 1969, government financial support for the CSAV has dropped off sharply. Until recently the CSAV has been concerned almost entirely with basic research, but under the present regime the CSAV program of applied research is being expanded. Resources previously used to support basic research are now being used to support applied work responsive to industrial needs. The applied research of the CSAV has included work proposed by top government agencies on problems too complicated and too diversified to be handled by industrial research institutes.

Most applied research is conducted in about 200 industrial research facilities under various economic ministries. Many of these facilities are connected with industrial plants in major industries. In some cases the research facilities conduct work for a group of industrial enterprises.

Most of the research done in the higher educational facilities is fundamental in nature, although the technical universities are engaged in some applied research. Some pressure has been exerted on the universities to bring their research programs under the government program for scientific development which has been set forth in the directives of the Government Plan for Development of Science and Technology.

The Czech and Slovak National Councils have parliamentary authority to pass legislation concerning science and research in relation to the requirements of the Czech and Slovak state economies. The federal government as the supreme executive power is concerned with the direction of planned expansion in scientific fields and with the general applications of research in the overall economic program. The government has the power to prepare long-range plans for science projects and assigns specific research work connected with the country's development to the relevant state agencies and scientific institutions. In these activities, the federal government is advised by the Czech and Slovak Ministries of Construction and Technology in collaboration with each of the academies of sciences and the Federal, Czech, and Slovak Planning Commissions. Although detailed planning of research and development activities has long been practiced by the Communist government, the present regime has insisted on stricter centralized planning than previously.

Only limited information is available on the financing of scientific and technical activities in Czechoslovakia. Government support for scientific research, including funds available for the CSAV, has been cut back drastically in recent years, and the degree of accountability for expenditures has increased greatly. Funding has been controlled by antiliberals since at least 1971. Cuts in funding have led to infighting among competing scientists, and only those with strong party connections prosper. Research and development spending is being made more responsive to industrial needs.

According to the Czechoslovak Federal Statistics Office, total spending for research and development

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by the federal and state governments amounted in 1972 to US$1.56 billion (using the official but unrealistic rate of exchange of 7.20 korunas = US$1.00), of which about 80% was expended in the Czech state. The amount appears to be excessive and probably includes items not properly included under research and development. Funds for research at the universities are not separately stated but are included in their annual operating budgets. Approval of funds for the academic sector is based on reviews by high-level committees consisting of the Deputy Ministers of Technology, Finance, Planning, and the Interior. In view of this, approvals require considerable time, resulting in delays in initiation of research programs.

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

The quality of scientific and technical education in Czechoslovakia is good. High standards are maintained in spite of the overcrowding that prevails at some institutions. The Czechoslovak Government in 1972 cut back drastically on university enrollments in science and technology. At one institute, for example, admissions were down from 100 per year to 20. University-level scientific and technical training is provided by nine universities and technical schools, with a total enrollment of about 74,000. These institutions are (in descending order of enrollment): Charles University, Prague; Comenius University, Bratislava; Technical University of Prague; Slovak Technical University, Bratislava; Purkyne University, Brno; Palacky University, Olomouc; College of Chemical Technology, Prague; State College of Mining and Metallurgy, Ostrava; and College of Chemical Technology, Pardubice. There are also several specialized colleges in agriculture and engineering. All higher education, including postgraduate training, is free; stipends, based on need and academic excellence, are designed to direct students into scientific and technical specialties according to quotas set by the government and based on anticipated manpower requirements.

Scientific and technical education in the universities and technical colleges includes 3 years of general mathematics and science courses, 2 to 3 years of specialization supplemented by industrial practice, and preparation and defense of an undergraduate thesis covering a design or technical process. Graduates bear such titles as diploma physicist and diploma engineer. A 7-year program of reform of higher technical education, instituted in 1959, was designed to emphasize the program of practical work and to decrease excessive specialization. Approximately 10,000 students were being trained in the fields of science and technology at the universities and the CSAV in 1968.

There is ample opportunity for postgraduate study in Czechoslovakia. Both the universities and CSAV institutes offer programs leading to the Candidate of Sciences degree. Some postgraduate students enroll in the scientific *aspirantura* program, which is offered in both full-time (regular) and part-time (external) study. The regular *aspirantura* is a 3-year program consisting of 18 months of study and examination and 18 months in preparation of a scientific dissertation, which must be a significant scientific contribution. The external *aspirantura* has no time restriction on the period of study and permits young specialists to work full time as laboratory assistants and technicians while attending courses and seminars at night. Less formal postgraduate training also is offered through a program of scientific preparation of selected personnel at scientific research institutes and of selected assistants working on assigned projects at higher schools.

Holders of the degree of Candidate of Sciences (more or less equivalent to the Ph.D. degree in the United States) may, after additional research experience, submit a doctoral dissertation for the degree of Doctor of Science. This is the highest degree awarded in Czechoslovakia, and the doctoral thesis is intended to be a profound and original scholarly work.

Much of the responsibility for the training of scientific research workers rests with the CSAV, which utilizes many of the country's science graduates and competes with universities, ministerial institutes, and industry for their services. As required by law, the CSAV provides scientific instruction and cooperates with the universities in the selection and training of qualified scientific workers in both basic and applied sciences. In 1971 there were approximately 1,800 individuals in the CSAV who were engaged in full- and part-time training activities. In 1966, 34 *aspirantura* in the CSAV program received the degree of Doctor of Science and 267 received the degree of Candidate of Sciences. The CSAV has had some difficulty in recent years in placing some of its graduates. It has tended to absorb the best researchers in the country. Therefore, many of the outstanding men in Czechoslovak research are identified with CSAV institutes, which employ a total of about 16,000 persons at various professional levels. Of this number, approximately 7,000 have advanced degrees. Employment of scientists within the CSAV who do not

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adhere to the regime's political line is controlled by 6-month contracts subject to renegotiation before renewal.

Most of the important CSAV institutes are in the Prague area, including the Microbiology Institute and the Institute of Organic Chemistry and Biochemistry, each employing about 400 scientists and technicians; the Institute for Macromolecular Chemistry, which had about 340 employees in 1969; and the Institute of Solid-State Physics.

Czechoslovakia does not appear to be faced with the problems of shortages of technical manpower. In fact, it produces more scientists, particularly chemists, than it can use effectively, and as a result many scientific graduates have accepted positions in other countries. Others have accepted positions in Czechoslovakia outside their field of specialization. In spite of the purges and defections, the scientific and technical manpower situation has not deteriorated significantly. The younger scientists have filled the gap left by the loss of about 1,000 research scientists and technicians since 1968 through resignations, dismissals, and emigration because of political factors. The total number of persons engaged in research increased from about 124,000 in 1965 to about 147,700 by the end of 1971. Approximately 13% of the total are associated with the CSAV and the affiliated SAV, 64% are employed by industry, 4% are concerned with construction, and the remainder are in such areas as health, agriculture and food processing, transportation, and communications.

Research facilities at the various centers and laboratories are quite modern. Some of the CSAV institutes and the institutes under the government ministries have the best equipment and facilities, whereas the facilities of the higher educational institutions tend to be less modern except in those cases where applied research is being done. The CSAV Institute of Nuclear Research at Řež[1] is well equipped with a research reactor, cyclotron, accelerator, modern betaray spectrographic equipment, and electronic instrumentation.

Czechoslovakia has a good capability for production of modern instruments and is able to supply other Communist countries. The government is aware of the fact that many of the CSAV institutes are located in old buildings and are short of laboratory space and has earmarked future funds for new buildings and equipment.

[1]For diacritics on place names, see the list of names on the apron of the Summary Map in the Country Profile chapter.

D. Major research fields

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

Czechoslovakia's capability for weapons research and development exceeds that of other East European countries, but it is very limited when compared with international standards. Soviet pressure has diverted the nation's resources away from systems development; consequently, most of its operational combat weapons are being supplied by the U.S.S.R. The greatest capability exists in the development and production of small aircraft and ground weapons. Although shipbuilding activity is underway at the Kimarno yards, evidence is lacking to indicate any naval weapon application or association.

The Czechoslovak aircraft industry leads the Warsaw Pact in the development and production of small utility, sport/aerobatic, and jet trainer aircraft. The output of jet trainers is sufficient to meet Warsaw Pact requirements. The Czechoslovak L-29 Delfin (MAYA) single engine, two-seat aircraft (Figure 2) has been the standard jet trainer for the Warsaw Pact forces, and as of March 1973, approximately 3,500 L-29's had been produced at the Vodochody plant in Prague. However, the L-39 advanced jet trainer, designed as a follow-on to the MAYA, has entered production and has been selected as the advanced jet trainer for the Warsaw Pact; 1,500 of these subsonic, two-seat tandem, single-engine aircraft are being built (Figure 3). Also in early 1973 the Czechoslovaks signed an arms agreement to provide 50 of these aircraft to Iraq. Production of the L-410 Turbolet light transport (Figure 4) has increased to three per month at the Kunovice plant, with a total accumulative production approaching 50 aircraft. The Czechoslovaks are making a strenuous effort in several European countries to market the L-410.

Continuing interest in the development of rotary-wing aircraft is reflected by the efforts of Czechoslovakia's Aero Group, which is building several prototypes of the new HC-4 helicopter at its Orlican Plant in eastern Bohemia. Essentially a derivative of the experimental HC-3 five-place helicopter of about 1960-61, the newly designed HC-4 offers increased capacity of up to seven places and is powered by a 700 shaft-horsepower Walter M-601 turbine engine. There is a possibility of Czechoslovakia's entering into a cooperative program with the Polish aircraft industry in the production of the HC-4.

The Czechoslovaks have a limited capability for aircraft engine research and development, and most of

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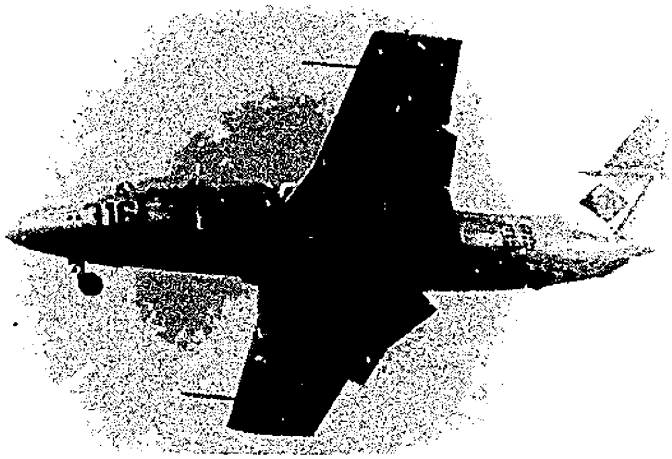

FIGURE 2. L-29 Delfin (Maya) jet trainer (C)

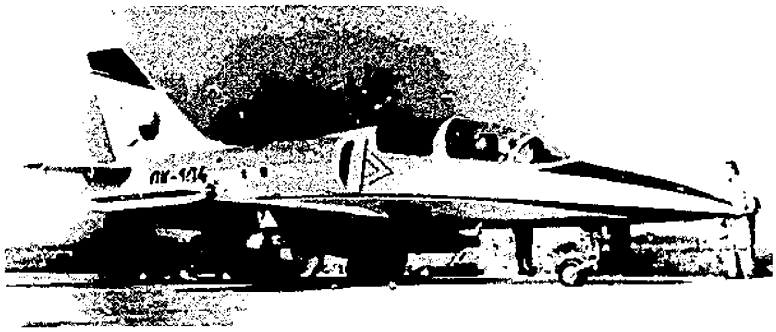

FIGURE 3. L-39 advanced jet trainer (U/OU)

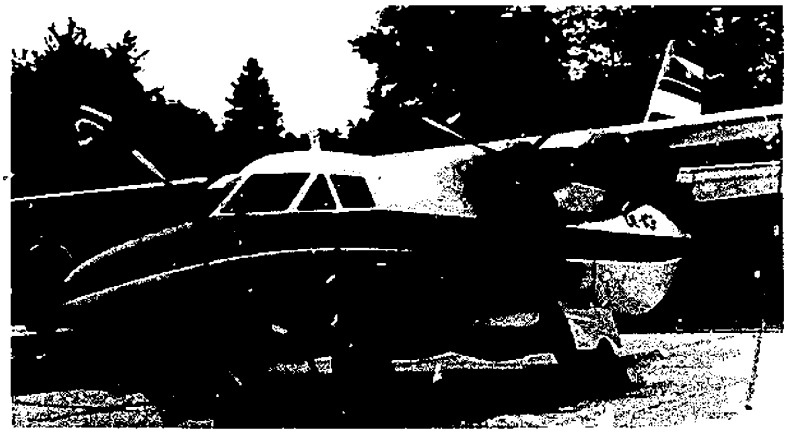

FIGURE 4. L-410 Turbolet light transport aircraft (U/OU)

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this capability is in the modification of foreign engines to meet local requirements. Current efforts focus upon modifying Canadian-built Pratt and Whitney PT 6A-27 gas turbine engines, developing the native designed M-601 engine as an optional engine for the L-410 turbolet transport, and the further development of the Soviet-designed AI-25 bypass engine for the L-29 and AI-25W for the L-39. Several small reciprocating aircraft engines are being developed and/or produced for the smaller aircraft previously mentioned. A high bypass turbofan engine developing 9,000 pounds of thrust is reported in design. Although purely of native design and intended for domestic applications, all segments of this program are controlled by the U.S.S.R. Ministry of Aviation. This engine is expected to enter production in about 5 years.

Aerodynamic research associated with development of air-breathing engines is done by a division of the Aeronautical Research and Testing Institute at the Motorlet complex. The institute is virtually the only organization in Czechoslovakia doing applied research in aerodynamics, and nearly all of this work is in direct support of industry. Facilities include several subsonic wind tunnels, a supersonic tunnel, and a shock tube. Over the years, the above institute has conducted extensive investigations on boundary layer control, particularly in its application to STOL-type aircraft. Some of this research was devoted to the development of blown slot and slotted flap systems. Although the research program was considered a success, neither system has been incorporated in production of aircraft.

Basic research in the propulsion field is accomplished primarily by the Institute of Thermodynamics of the Academy of Sciences. For nearly 10 years, this institute has conducted research in turbine design.

Czechoslovakia has a relatively strong capability in rocket propulsion research and development, and it continues to lead other East European Communist countries in solid-propellant technology. Development activity is devoted almost exclusively to double-base propellants. However, extruded composites containing ammonium nitrate have been developed, but no information indicates research and development of propellants employing ammonium perchlorate and elastomeric binders.

In October 1972 the Czechoslovaks displayed an adaptation of the Soviet 122-mm, 40-round multiple launcher. The Czechoslovak weapon features a powered reloader to fire a second 40-round salvo and displace within three and one-half minutes. The system, mounted on the 14-ton 8x8 Tatra 813 chassis, is the finest multiple rocket launcher in the world. A considerable number of these systems are in use with the Czechoslovak Army. The Pardubice Explosives and Solid Motor Development and Production Plant is currently producing the Soviet-designed Malyutka wire-guided, antitank rocket, which is equipped with two solid-propellant motors.

The sounding rocket development previously reported in progress at the Antonin Zapotocky Military Academy in Brno apparently was eliminated at the time of the August 1968 invasion; the rockets were of low performance compared with similar Soviet rockets. Since 1968, no information has been received on the status of this program.

Czechoslovakia has shown only limited interest in liquid rocket propellants. The Institute of Inorganic Synthesis, Rez, has conducted research under Soviet sponsorship on boron hydrides (boranes) and on hydrazine-borane adducts in rocket fuels. Part of this work was devoted to improving the Soviet manufacturing process for pentaborane and decaborane. The only other activity with propellant association is a liquid oxygen production capability at chemical plants located in Zaluzi and Sokolov.

Czechoslovakia has the industrial potential to produce guided missiles. This potential has not been developed, however, because of the restrictions imposed by the Soviet Union which prohibit indigenous weapon development activity. The research being conducted on missile systems is generally of a basic nature, and the only applied research being done is related to those areas authorized by the Soviets. These include work on unguided air-launched and salvo-fired rockets. Unconfirmed reports cite a new missile similar to the Soviet SA-7/Grail being produced in a joint effort with the U.S.S.R. The missile was described as a shoulder-launched, low-level antiaircraft surface-to-air system. The composite propellants in the booster and sustainer of the system are comparable to the best found in Western technology.

Since World War II, Czechoslovakia has demonstrated an excellent capability for the design and development of infantry and artillery weapons, a variety of which are in use by the ground forces. Among Warsaw Pact nations, the Czechoslovaks alone have equipped their army with small arms that are entirely of their own design. A new universal small arms family was announced recently. Variants include an assault rifle, light and heavy machine guns, and a tank machine gun. It is undetermined whether Czechoslovakia, a respected small arms exporter, will use the new arms to replace existing inventories of already adequate weapons or offer the new family for immediate export sales.

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The Czechoslovak ammunition industry does not rely solely on copies of Soviet-produced ammunition, but has and continues to maintain a domestic design capability if improvement is required. This is understandable because the munitions industry has long been independent and highly regarded throughout the world, so much so that Nazi Germany simply confiscated the plants and continued production of Czechoslovak native designs. The ammunition research and development effort develops and produces large-caliber ammunition of virtually every size available to the Warsaw Pact countries. The quality of the ammunition and fuzing in many instances seems to rank above that produced by the U.S.S.R. This trend undoubtedly will continue into the foreseeable future. Research appears to be concentrated on the development of propellants and explosives, and work is underway on combustible cartridge cases. Czechoslovakia, one of the leading Communist countries in research and development of mine warfare equipment, has developed and produced a family of antitank and antipersonnel mines which employ conventional fuzing techniques.

Czechoslovakia has not developed an original tank design but has continued to modify Soviet medium tanks, manufactured under agreement with the U.S.S.R. OT-64 wheeled armored personnel carriers, possibly based on the Tatra 813 chassis, and armored reconnaissance vehicles employed by the Czechoslovak armed forces are similar in design and operational capability to their Soviet counterparts. These lightly armored vehicles were developed by the Czechoslovaks in collaboration with Polish and Hungarian engineers. The current in-service, full-tracked OT-62 armored personnel carrier is a copy of a Soviet counterpart vehicle with modifications to meet Czechoslovakia's specific mission requirements. Reportedly, the nation also produces a version of the latest known Soviet full-tracked infantry combat vehicle.

Czechoslovakia is capable of performing research and development necessary for the production of military motor transport vehicles ranging from light to heavy duty trucks. Research and development for the Czechoslovak automotive industry were conducted by the Automotive Research Institute, with research on military vehicles being the responsibility of the Military Technical Institute under the Ministry of National Defense. Most research work is performed at the research facilities of the Skoda, Tatra, and Praga plants, which have good equipment and staffs. Vehicle design is geared to provide military transport vehicles of improved performance and mobility. This is evidenced by the utilization of such items as tire inflation systems, locking differentials, wide-profile tires, power braking, power steering, and high power-to-weight ratios in vehicle designs.

The Soviet Gaz(Uaz)-69 is the only foreign vehicle used by the Czechoslovak armed forces; it and the Tatra 805, a 1.5-ton 4x4 truck, are the only gasoline-fueled military trucks in Czechoslovakia. All other trucks are diesel fueled. Current research projects involve continuing development of the Tatra 813 and Tatra 148 families of vehicles and product improvement in current production of trucks in the medium-load range. Feasibility studies are continuing on unconventional design, high mobility, and off-road vehicles in the light- to medium-load range. Engine research programs include multifuel engine development, direct injection air-cooled diesels, and a gas turbine for heavy trucks.

Research and development in military engineer equipment are broadly based, and Czechoslovakia is the only Warsaw Pact country that has developed a family of river-crossing equipment independently of the U.S.S.R. This equipment includes reconnaissance and assault boats, powerboats, light and heavy bridges, tank-launched scissor bridges, and Bailey-type panel bridges. Most recently the Czechoslovaks have displayed a new multispan truck-launched bridge mounted on the Tatra 813. The bridge appears superior to the similar Soviet TMM model. Fixed bridges of fiberglass and aluminum reportedly are under development. In other types of engineer equipment, the country has a considerable capability for the development of virtually all types of engineer construction equipment. Actual research activities, however, have been curtailed in this area because of budgetary limitations.

The Czechoslovak Army has an impressive capability for surveying, photomapping, and topographic mapping, primarily in support of artillery and missile units. Most of the equipment in service is of Soviet, Hungarian, or East German origin. The Czechoslovaks have built special-purpose mobile mapping vans based on the Praga V3s truck. These mobile vans include photo lab, photo compilation, and map reproduction models. Some research is conducted by the Military Topographic Institute and the Military Geographic Institute.

Among the Communist countries, Czechoslovakia is second only to the U.S.S.R. in the development and production of military and sport parachutes. Czechoslovakia relies more and more on its own research institutes, with major efforts being made in the development of synthetic fibers and plastics with

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applicability in the airdrop field. The country's largest developer and producer of parachutes is the Kras firm, which has factories and research centers located near Brno. Kras has been commended for the development of outstanding military and sport parachutes during the past 3 years. Research and production of parachute material is conducted by the firm ***Stuhy a Prymky***. Its production rate of nylon and perlon parachute cording, webbing, and strap material for the armed forces is estimated to exceed 32 million feet per year.

In recent years Czechoslovakia has shown increased capabilities for development of sophisticated POL-handling equipment for military use. Among these are the design, development, and production of various types of collapsible storage containers that can be parachuted, transported by truck, floated on water, or towed by tugboat. Other POL-handling equipment required for support of military requirements is of the conventional type produced locally.

In the field of individual clothing and equipment, the army utilizes new synthetic materials, plastics, and finishes in the components of combat clothing and individual equipment to increase durability and to better serve functional purposes, such as protection against the elements, climatic extremes, corrosion, and visual and photographic detection. New impregnating agents have decreased the water permeability of clothing, and new fiber blends and finishes have made them resistant to flame, grease, and abrasion. U.S. research and development agencies have determined recently that the Czechoslovak Army's combat suit represents highly significant advances in clothing design and camouflage capabilities. There is no known research underway on materials-handling equipment, rations, packaging, and tentage specifically for military use.

2. Biological and chemical warfare (S)

Czechoslovakia has the best developed microbiological capability among the Communist countries. Many of the most competent researchers have been engaged in research that has BW potential, in particular, BW defense. During the early 1960's, authorities initiated an accelerated defensive BW research program that included research on the rapid identification and decontamination of BW agents and in immunology. Much of the rapid identification work was completed during 1965-69. In the early 1970's, emphasis was on immunology and therapy of viral and rickettsial diseases and hybridization of viruses.

Scientists at the Military Institute of Hygiene, Epidemiology, and Microbiology, Prague, which is subordinate to the Ministry of National Defense, have been conducting research on a number of microorganisms of potential BW significance. This research includes the viruses causing Monkey B disease, lymphocytic choriomeningitis, tickborne encephalitis, smallpox, rabies, Venezuelan equine encephalomyelitis, and rubella. Work also has been done with ***Pasteurella tularensis, Bacillus anthracis, Leptospira*** species, and Q-fever and typhus group rickettsia. Many of these are well known candidate BW agents, and some are exotic agents which pose no public health problems in Czechoslovakia.

The Czechoslovaks are well versed in the techniques of microbiological aerosols and have conducted aerosol infection studies on many candidate BW agents. The Czechoslovaks are working on aerosol phenomena, including cloud physics, industrial gas cleansing devices, respiratory aerosol penetration, sampling and filtration of microbial aerosols, and the differential thermal analysis of aerosols. Some research on aerosol vaccines has been accomplished at the Military Medical Research and Postgraduate Institute (formerly Military Medical Academy Jan Purkyne) in Brno. Although the Czechoslovaks were once leaders in aerobiology, the overall level of aerosol research appears to appreciably lag behind Western efforts. In biomedically oriented aerosol research, however, excellent work continues to be done by some individual scientists.

Czechoslovakia has signed and in mid-1973 ratified the 1972 United Nations convention on the prohibition of the development, production, and stockpiling of bacteriological (biological) and toxin weapons and on their destruction. This convention permits research with microbial or other biological agents and toxins (whatever their origin or method of production) for prophylactic, protective, or peaceful purposes. Despite budgetary and personnel cuts in the scientific domain and the signature of the United Nations convention, Czechoslovakia is expected to continue with research and training in a realistic BW defensive program.

Research related to chemical warfare (CW) is oriented primarily towards the study of the mechanism of action of nerve agents, natural poisons, and psychotropic compounds. Excellent research on the pharmacology and toxicity of stereoisomerism of organophosphorus compounds could well support a nerve agent development program. Natural poisons, particularly the bacterial toxins, and the hallucinogenic plant alkaloids are being studied extensively. Research on bacterial toxins (e.g., botulinum toxin) may lead to the development of such

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toxins as potential CW agents. Much of the basic research on plant hallucinogens concerns the effects of indole-based alkaloids on the higher nervous system. In addition to their studies on LSD-25 (lysergic acid diethylamide), new hallucinogenic drugs, such as piperidylglycolates, are being synthesized and tested possibly as candidate CW agents.

To maintain their strong CW defensive posture, the Czechoslovaks have very active programs for devising new detection, decontamination, and protection equipment. More sensitive and mechanically reliable automatic alarms based on enzyme reaction are being developed for detection of nerve agents. Work on detection of aerosols, which might be CW-oriented, includes scintillation particle counters tuned to identify defined chemical compositions, chemically treated membrane filters for spot testing of collected aerosols, and counters to measure reflected light impulses from particles. Prophylactic and therapeutic research for more effective treatment of nerve agent poisoning appears to have a high priority.

At least five institutes are engaged in CW-related research and development: the Chemical Warfare Research and Development Center 070, which is collocated with Antonin Zapotocky Military Academy in Brno; Military Research and Postgraduate Institute, Brno; Charles University, Hradec Kralove; Zemianske Kostolany Chemical Plant, Zemianske Kostolany; the Military Veterinary Research Institute, Prague; and the Institute of Physical Chemistry, Prague.

The Chemical Warfare Research and Development Center 070 appears to be the major facility responsible for the development of personal protection, decontamination, and detection equipment. Activities at this facility include development of mobile field laboratories, CW agent detector kits and alarms, and thin-layer chromatographic and flurometric techniques for the systematic detection of nerve agents, mustard, and lewisite. The center directs field testing of protective equipment at Vyskov, east of Brno. The Chemical Troops Directorate, which is subordinate to the Ministry of National Defense, directs the center.

The primary CW research mission of the Military Medical Research and Postgraduate Institute is to test the effectiveness of agents and to develop prophylactic and therapeutic compounds to protect against agent poisoning. Research activities include studies on inhibition of brain acetylcholinesterase by sarin of reactivation kinetics of sarin—inhibited acetylcholinesterase by bisquaternary pyridinemonoaldoximes. The effects of LSD-25 on the central cholinergic functions as well as synthesis and testing of new psychotropic compounds are also under study.

The facility at Zemianske Kostolany reportedly has laboratories capable of producing up to 100-kg pilot plant lots of CW agents. The facility reportedly conducts research on antidotes for CW agents, develops chemical agent detector kits, and also maintains an animal farm for experimentation. Experimental data are forwarded to the Antonin Zapotocky Military Academy.

3. Nuclear energy (C)

Czechoslovakia has established a nuclear energy program restricted to research and the development of the economic applications of nuclear energy, particularly the production of electric power. The program has been hampered by the limitations of funds and the lack of some basic materials and equipment, but it has progressed with assistance from the Soviet Union. Under terms of a bilateral agreement for nuclear research concluded in 1955 with the U.S.S.R., Czechoslovakia acquired a research reactor, a cyclotron, and aid in the construction of a nuclear power station. The country also has profited from membership in the IAEA and the Joint Institute of Nuclear Research at Dubna, U.S.S.R.

The Czechoslovak Atomic Energy Commission was established in July 1955 to direct and coordinate the development of nuclear energy. The actual program is carried out by a number of scientific, governmental, and industrial organizations, chief of which is the Institute of Nuclear Research (INR) at Rez. The principal facility of the INR is a Soviet-supplied tank-type research reactor, which went into operation in September 1957. The reactor is fueled with 10% enriched uranium fuel, and its design power level of 2 megawatts (MW was raised to 4-5 MW in 1964). The INR also is equipped with a Soviet-supplied 120-centimeter diameter cyclotron able to produce 8-megaelectronvolt (MeV) proton and a Czechoslovak-designed 5-MeV Van de Graaff accelerator. These facilities are used for research, training, and the production of radioisotopes. The research programs at INR include reactor design, basic nuclear physics, radiochemistry, and the chemistry and metallurgy of reactor materials and components. In 1966, construction was begun at Rez on a heavy water-moderated, natural uranium-fueled, zero-power reactor, named TR-O, which was to be used to test fuel element designs for power reactors of this type. The TR-O was expected to go into operation in 1970, but its completion was delayed until July 1972.

The Nuclear Energy Development Section of the V. I. Lenin Works (Skoda Works) at Plzen designed and fabricated a zero-power experimental reactor, which

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was inaugurated at Bolevec on 8 May 1970. This reactor, the SR-0A (Skoda Reactor OA), is light water-moderated and uses 10% enriched uranium fuel supplied by the U.S.S.R. This reactor is used for reactor physics research and to train nuclear reactor operating personnel.

The Czechoslovaks envisaged an extensive nuclear power program, and construction of the first nuclear power station, the A-1, was started in 1958 at Bohunice, about 35 miles northeast of Bratislava. The A-1 has a gas-cooled, heavy water-moderated reactor fueled with natural uranium with an installed electric power capacity of 150 megawatts electric (MWe). Although it was begun as a joint Soviet-Czechoslovak venture, over the years it became a Czechoslovak project. The Lenin Works was responsible for the design and construction of the A-1 nuclear power station, although the U.S.S.R. supplied the fuel and heavy water for the reactor. While the A-1 was originally planned for completion in 1961, a number of difficulties were encountered, and the reactor finally went critical in October 1972.

Czechoslovakia had planned to base its nuclear power program on the A-1-type reactor, and the Lenin Works established sections at Bolevec, Zatisi, and Vochov, near Plzen, for research on and development of nuclear power stations. However, plans for the construction of additional reactors of the A-1 type have been dropped.

In April 1970 an agreement was concluded between Czechoslovakia and the U.S.S.R. for Soviet assistance in the construction of two nuclear power stations in Czechoslovakia, with a total installed electric power capacity of 1,700 MWe. Each station is to have two pressurized water reactors of the Soviet Novovoronezh 400-440 MWe type. The first station is under construction adjacent to the A-1 at Bohunice, with the reactors expected to be in operation in 1977 and 1978. The second station is to be built near the hydroelectric power station at Dukovany on the Jihlava River. The two reactors of this station are scheduled to go into operation in 1979 and 1980. The U.S.S.R. will supply the primary plant—the reactors and primary circuits including steam generators—while Czechoslovakia will be responsible for the secondary circuits including pumps, turbines, and condensers.

Plans call for the construction of 10 additional nuclear power stations between 1980 and 1990, with the installed electric power capacity to be 5,000 to 7,500 MWe by 1985 and 12,000 to 15,000 MWe by 1990. It is expected that Czechoslovakia will manufacture at least part of the primary circuit for these reactors as well as similar components for export.

The nation is cooperating in the Soviet fast breeder reactor development program, and a group was established at the Bolevec site for this work. Construction of the fast breeder type reactors in Czechoslovakia is envisaged for some time after 1990.

The principal applications of nuclear energy to date are the use of radioactive isotopes in research, medicine, and industry and the production of nuclear-associated equipment. Isotopes are produced at INR or imported from other countries and are prepared for distribution by the Institute for Research, Production, and Use of Radioactive Isotopes, Prague. A number of industrial organizations are making use of isotopes and radiation for research, production, and process control and testing, and a sizable industry has been created to provide nuclear equipment, including the Chirana Works in Prague, which manufactures medical radiation therapy instruments.

Uranium ore has been mined in Czechoslovakia since 1946, and virtually the total production has been sent to the U.S.S.R. Several thousand tons of uranium are sent to the U.S.S.R. annually in the form of high-grade ore and concentrates. Vast uranium reserves are located in central and northwestern Czechoslovakia, amounting to well over 100,000 tons of uranium. Czechoslovakia had planned to use its own uranium resources to fuel its nuclear power reactors. In 1966 the Institute for Nuclear Fuels and a pilot plant for fuel fabrication were set up at Minisek. However, the U.S.S.R. is to provide the natural uranium fuel for the A-1 reactor and the slightly enriched uranium fuel for the four reactors being built under the terms of the April 1970 agreement.

4. Electronics (S)

Czechoslovakia has a strong electronics research and development capability compared with other European Communist countries, equal to that of Poland, but slightly behind that of East Germany. In all aspects of basic research, however, and applications in particular, Czechoslovakia continues to lag behind U.S. efforts by at least 5 years. Much emphasis is placed on acquisition of Western technology and equipment as a basis for improving this capability.

Czechoslovak and Soviet research and development are closely allied through bilateral agreements. The nationalized civilian industry and the Czechoslovak Army conduct all research and development within the framework of a 5-year program. Plans for the development of military equipment must be approved by both the Technical Council of the Ministry of National Defense and the Soviet Army Chief of General Staff. Approved plans must subsequently be

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coordinated with the military section of the Council for Economic Mutual Assistance. In 1969 and early 1970, agreements detailing scientific-technical cooperation between the Federal Commission for Postal Services and Telecommunications of Czechoslovakia and the Ministry of Communications of the U.S.S.R. were signed. These agreements provide for the following: compatibility of automatic telephone systems control offices with standard communications networks; coope ation in planning of radio and TV networks; and coordinated efforts in transmission of color and black and white TV signals, in the design of cables, and in the construction of ground stations for satellite communications.

Czechoslovakia continues to emphasize communications research and development, and is providing some challenge to Hungary in the microwave field, especially in the capability to produce high-quality components, such as avalanche and Gunn diodes, in quantity. The major electronic research, development, and production facility is the Tesla Nationalized Enterprises in Prague. Military radio relay equipment, deployed extensively throughout the U.S.S.R. and to a lesser extent in other European Communist countries, has been reported as possibly developed and manufactured by Tesla and its affiliated organizations. One of these, the Tesla Telecommunications Research Institute, Pardubice, continues to accomplish considerable microwave research and development work on pulse position modulation (PPM) and pulse code modulation (PCM) systems.

Particular attention is devoted to the development of digital and secure communications systems using electronic encoding and West German teleprinters. Tesla developed and produced the 24-channel KPK-24 PCM system in the mid-1960's and followed in 1970 with the 32-channel KPK-32. Another of Tesla's major efforts is concerned with the development and production of air traffic control equipment for both airborne and ground installations. Automatic reconnaissance and direction-finding equipment was developed by an experimental research institute near Prague. Microwave measuring and test equipment up to and including the 8-millimeter band was developed and produced by the Radio Technical Institute at Opocinek, also a Tesla affiliate.

The Czechoslovaks continue to develop many types of electronic components, resulting from a moderate research and development program on electron tubes and solid-state devices. Also transistors, diodes, thin-film integrated circuits, and ferrite components are under development. Silicon products technology, such as silicon epoxy molding compounds for semiconductor devices, lag Western Europe by about 3 years. The Institute of Solid-State Physics, Prague, is investigating noncrystalline semiconductors, including liquid amorphous and chalcogenide glasses and amorphous germanium. The degree of success of these studies is not known, but the knowledge gained will enable production of transistors by evaporating semiconducting films of selenium and tellurium which, in turn, will benefit miniaturization and printed circuit technology.

Czechoslovak laser research compares favorably with that of East Germany but lags in areas of military device production and hardware development. Since 1963 Czechoslovakia has developed ruby, neodymium-glass, gas, semiconductor (gallium arsenide) lasers, and considerable interest is centered on helium neon lasers. A number of serially produced solid-state and gas lasers have been placed on the market. As part of its extensive research program in the communication field, the Institute of Radio Engineering and Electronics in Prague has studied laser transmissio of audio signals and modulation and detection of laser beams. Applications of lasers in the fields of range-finding, geodesy, mine surveying, ophthalmic surgery, and plasma heating are being researched. There is, however, no evidence of directed energy weapon development. The first Czechoslovak laser radar, intended for observations of artificial earth satellites, has been installed at the Ondrejov Astronomical Institute in Prague. The instrument, in operation since March 1972, incorporated the four-axis tracking concept developed separately in East Germany, the U.S.S.R., and the United States. The U.S.S.R. furnished the tracking mount, and the laser is a Czechoslovak ruby device rated at about 2 joules with a 20-nanosecond pulse every 10 seconds. The Institute of Radio Engineering and Electronics is investigating the communications potential of lasers.

Most of the avionics equipment being used in Czechoslovakia was obtained from the U.S.S.R. and to a lesser extent from Western countries. Nevertheless, Tesla has been involved in the design of both airborne and ground installations for air traffic control, and their effort has concentrated on the development and production of precision approach radars.

The Aviation Research Institute (LVU) is reportedly developing certain instruments for the Czechoslovak-designed L-159, a delta wing twinjet, low-level attack aircraft. Details are sketchy, but the work possibly involves the development of such equipment as an instrument which would constantly plot the aircraft

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position on a display device in the cockpit, airspeed indicator, a laser altimeter, an autopilot, and a flight recorder.

Metra Electrical Measuring Instruments Company was reported to be manufacturing electronic countermeasure equipment designated "Wobler." The equipment employs a sweep method which constantly changes frequency and can be operated via remote control from the pilot's compartment.

The Czechoslovaks have developed and deployed the only operational ground-based ELINT time-of-arrival system in use in the world. It has been in use at least 5 years. From three or more ground sites, quite accurate locations of U.S. or West German radars can be obtained if coincident intercept can be obtained. The advanced ground sites are connected with a direction-finding processing center by video link operating at 8 gigahertz. Designed by the Military-Technical Directorate and operated by the military exclusively, the system has only fairly recently received greater Warsaw Pact recognition. It has been deployed along the Czech-German border and represents a rather considerable investment and technical accomplishment in the passive electronic countermeasure/ELINT field.

The Czechoslovaks have displayed originality and high capabilities for designing digital computers, but the completion of prototypes and initiation of production in industry have been too slow to provide computers competitive with foreign models. Heavy dependence on foreign systems is still necessary to meet many normal domestic needs. Since the early 1960's, important work has been underway in the military sector, for example, in modern command and control procedures, yet no field military automatic data processing systems are known. The Ministry of National Defense has at least two research centers concerned with the development of computers, applications techniques, and specific problems of logistics, training, and related military activities.

The main administrative authority for Czechoslovak computer activity is probably the Ministry of Industry. The Research Institute of Mathematical Machines (VUMS), Prague, is the primary design facility and the most important contributor to Czechoslovak computer research and development. It has developed excellent peripheral equipment; its tape readers are the best in the Warsaw Pact countries; its line printers are in domestic use and exported to the U.S.S.R.; and punchcard equipment is used in various army installations for control of spare parts and similar logistic applications. Basic research is conducted also by the CSAV's Institute of Information Theory and Automation, Prague.

Products of the VUMS have included a variety of special-purpose, data-processing devices and a large, high-precision analog computer called ANALOGON, but the most important results have been the small general-purpose MEDA analog computers, the small general-purpose digital computers SAPO, EPOS-1, EPOS-2, ZPA-600, and its smaller version ZPA-200, the MNP-10, and the DP-100, a small punchcard computer. The most recent Czechoslovak digital computer, the third-generation ZPA-600G/30, is claimed to approximate the IBM 360/30. Other analog computer developments have been the AP-3M and the AP-5. Czechoslovakia also has maintained a strong capability to develop input/output equipment for digital and analog machines.

5. Medical sciences (S)

The high quality of research in the medical sciences can be readily discerned. The Czechoslovaks maintain a superior level of competence, surpassing that of the other East European countries in most fields and qualitatively equal to that of the U.S.S.R. in microbiology and pharmacology. Despite the lack of well equipped laboratories and limited research funds, results achieved are remarkable. Productivity has been inhibited to some extent by the Soviet intervention in 1968, and since that time prominent scientists have been deprived of key positions as institute heads and leaders of research. Major contributions are being made in microbiology, biochemistry, physiology, pharmacology, and radiology.

Microbiological science is at a very high level. Research utilizes biochemical, biophysical, organic and physical chemical, morphological, and mathematical approaches. Major work is done at the Institute of Microbiology, Academy of Sciences, Prague. Tasks include study of cellular formation and reproduction, controlled proliferation of microbial populations, and genetic systems in life processes and in regulation of physiological states of the cell. Some of the best efforts are in the field of continuous fermentation. Fundamental studies have been contributed to the production of single cell protein by fermentation of petroleum hydrocarbons. Research in the immunology of infectious diseases is especially productive. Czechoslovakia's computerized epidemic-diseases surveillance system is recognized as one of the best in the world and has served as a pattern for adaptation by other countries. Research workers have succeeded in producing germ-free animals. Work on staphylococci and related infections is on a par with that done in Western countries, including the United States. The group working with insect hormones for

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control purposes is one of the largest and best of its kind in the world. Virology research is excellent on the structure of viruses, the incidence of tick-borne viruses of Europe and Asia, the development of vaccines, and the production of interferon. The major center for virology work is the Institute of Virology in Bratislava, which is a WHO Regional Reference Laboratory for Arboviruses.

Investigations in radiobiology include a well planned and executed study of the comparative radiotoxic and cancerogenic effects of radioisotopes as related to isotope half-life. Fine research is underway on the metabolism of isotope labeled blood components, the distribution of radioisotopes, the effects of whole-body irradiation, the genetic code, and modeling of living processes. Interesting studies are underway on the use of enzymes in the treatment of radiation sickness to neutralize radiation doses and on the cardiovascular effects of radiation damage. The country is shorthanded in laboratory personnel, but many radiologists have received excellen training in both the United States and Western Europe. An important center for radiation work is the Institute of Biophysics and Nuclear Medicine, Charles University, Prague.

The high standard of research in biochemistry can be attributed in part to the fact that a large number of Czechoslovak biochemists have been trained in the United States. The scientists are bright and imaginative, but they are severely handicapped by shortages and inadequacy of equipment. Biochemists are contributing exceilent studies on the fractionation of immunoglobuiins, an understanding of the problems of transplantation immunology, the effect of physical factors on blood during extracorporeal circulation, and the physiological effects of electromagnetic irradiation. Important contributions are being made in the analysis of protein and polypeptide structures and the partial synthesis of enzymes. There are genetic studies of industrially useful organisms to isolate desirable antibiotic-producing strains and to develop a system to regulate production of nucleic acid and protein macromolecules. Extremely pure and highly active enzymes have been isolated.

Research in pharmacology is given high priority and is directed primarily to support of the drug industry. The Institute of Hygiene and Epidemiology in Prague is pursuing a program for the evaluation of pharmacological agents, a program which exploits the facilities of the Central Computer Center of the Institute of Applied Mathematics, Prague. Proposals have been made to WHO to formalize standardization of drug assessment procedures. The pharmaceutical industry has four specialized research units in addition to 13 production enterprises. A major center of investigations is the Research Institute of Pharmacy and Biochemistry, Prague. The nation is one of the world's largest developers of ergot alkaloids, and research on these agents is directed to their action on central regulation of physiological functions.

Research in the field of chemotherapy of cancer involves analysis of selective toxicity of agents in cancer cells. Chemical approaches to cancer control are very sophisticated. Czechoslovakia has done good work on antimetabolite development, and its competence in organic chemical synthesis of drugs is of the same caliber as that of the United States. Difficulties are encountered in obtaining reagents and chemicals. Other areas of attention are psychopharmacological agents, prophylaxis of upper respiratory infections, radiopaque agents and steroids

Able and imaginative work is being contributed in physiology and neurophysiology. Research personnel are well trained, but laboratory equipment is difficult to obtain. The Department of Physiology has developed a technique for assessment of subjects suffering from a variety of neurological, physiological, and psychophysiological disturbances. Collaborative studies with the United States in this area are being initiated. Some good equipment, imported from West Germany, is available for the study of pulmonary functions. Wide recognition has been given to Czechoslovak work on the physiology and pathology of the nervous, muscular, and reproductive systems and mechanisms of adaptation to stress. Exhaustive study has been made on the limits of human endurance when subjected to extreme physical and mental stress under laboratory and real conditions. Physiologists have done fundamental research on the effect of long-term hypoxia on the human heart.

Clinical research is of good quality. Research on medical electronic devices must depend on the use of imported materials. An important clinical study center is the Institute of Clinical Experimental Medicine in Prague which now incorporates the former institutes of experimental therapy, human nutrition, cardiovascular research, and experimental and clinical surgery. An advanced neurosurgical clinic, established at the Faculty Hospital in Hradec Kralove, is equipped with West German as well as native instrumentation. Czechoslovakia has made a major contribution to the development of a soft contact lens. Important studies are being made by the Institute of Human Nutrition on the nutritional value of local foods.

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Military medical research, of good quality but limited in scope, is conducted in both military and civilian facilities. Principal military medical research facilities include the Institute of Aviation Medicine, Prague; the Institute of Radiology and the Military Research and Postgraduate Institute, Hradec Kralove; the Central Military Hospital and the Military Institute of Hygiene, Epidemiology, and Microbiology, both in Prague. The major fields of military medical research include operational aviation medical—neurophysiological and psychological aspects, hypoxia, hyperventilation, and hypocapnia (a reduction of the amount of carbon dioxide in the blood) related to flight safety in high-performance aircraft, and on weightlessness; wound healing; drug-induced radiation immunity; protection against ionizing radiation and BW/CW agents; diagnosis and treatment of brain tumors; drugs to counteract the effects of LSD; and research on viral diseases. Benefits are also derived from civilian-conducted research and development having military implications. The general attitude of military medical personnel toward in-service research is favorable.

6. Other sciences

a. Chemistry and metallurgy (S)

The Czechoslovaks have an outstanding capability in chemical research. Their publications presently account for 2% of the world's chemical publications, slightly more than Poland but less than the U.S.S.R. The research program is well diversified, covering all of the important branches of chemistry. Both fundamental and applied aspects are included, and much of the applied research is directed toward meeting the needs of the expanding chemical industry. Most of the fundamental chemical research is conducted in the universities and in the many research institutes of the CSAV, while most of the applied chemical research is conducted at the numerous research laboratories and institutes associated with chemical and other industrial plants under the government ministries. In addition to the universities, the College of Chemical Technology in Prague and the Slovak Technical University are important centers for fundamental chemical research.

Czechoslovakia is strong in organic chemistry, including organic synthesis and physical organic chemistry. Much of the country's organic chemical research is done in support of the substantial organic chemical industry, which is interested in organic intermediates, pharmacologically active compounds, agricultural chemicals, dyes and pigments, and high polymers. Excellent organic chemical research is done at the CSAV Institute of Organic Chemistry and Biochemistry, Prague. At this institute, the country's most outstanding organic chemist, Dr. Frantisek Sorm, had done extensive research on steroids, the structure and function of proteins, the preparation of cancerostatic agents for leukemia, insecticidal esters, and recently on natural and synthetic materials with insect hormone activity. In cooperation with his associate, Vlastimil Herout, another prominent organic chemist, he has done considerable research on the isolation, identification, preparation, and proof of structure of terpenes and other plant substances.

Some of the foremost synthetic organic chemical research is done by Miroslav Protiva and his colleagues at the Pharmaceutical and Biochemical Research Institute in Prague. Their work on pharmacologically active organic compounds has included studies on the synthesis of tranquilizers and antidepressants, antihistamines, analgesics, and various heterocyclic compounds containing sulfur and nitrogen. The College of Chemical Technology in Prague maintains a strong research program in organic chemistry, including studies on asymmetric reactions, reactions in the pyridine series, and liquid phase catalytic hydrogenation of organic compounds (including studies with sulfide catalysts). Also physical organic investigations are done on alkaloids, amino acids, and peptides by Karel Blaha, an authority on organic nomenclature. His work includes infrared and nuclear magnetic resonance spectroscopy, stereochemistry and conformation analysis. Extensive work on organosilicon compounds has been conducted by Vladimir Bazant at the CSAV Institute of Chemical Process Fundamentals, Prague.

There is significant work at Charles University on anhydro sugars, at Palacky University on alkaloids, and at the Slovak Technical University on organic peroxides and isothiocyanates. Otto Exner at the Hevrovsky Institute of Physical Chemistry and Electrochemistry, Prague, is prominent in research in physical organic chemistry including studies on inductive effects, dipole moments, structure and configuration, and additive physical properties of organic compounds.

Research on organic polymers has reached significant proportions. The most important research is done at the CSAV Institute of Macromolecular Chemistry in Prague and at the Research Institute of Macromolecular Chemistry in Brno. Otto Wichterle and others at the CSAV institute have done extensive work on vinyl polymerizations, the polymerization of caprolactam to polyamides, degradation of polymers,

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chemistry of steelmaking, refining (including basic oxygen and direct reduction), continuous casting, the statistical analysis of metallurgical processes, and quality control. Extensive studies of foundry technology, including solidification studies, elimination of casting defects, and molding sand practice, have been conducted. Ferrous physical metallurgical work has included the development of high silicon electrical purpose steels and means to produce them, the investigation of stainless steels for high-temperature service, the study of the transformation kinetics in high-strength, low-alloy steels, the development of nickel-base, high-temperature alloys for aircraft gas turbine applications, and the study of thermal mechanical treatment to improve the strength properties of structural alloys. On the latter subject, the Czechoslovaks apparently have not reported the notable improvements in strength claimed by the Soviets.

Extensive research has been done on metalworking and processing. Recent work has included the effect of deformation rate on the hot rolling and forging of steel products and on the extrusion of steels and nonferrous alloys. Extensive welding research has been carried out at the Welding Research Institute in Bratislava. This facility is one of the premier welding research establishments in the world, and it compares very favorably with the Paton Institute in the U.S.S.R. Research activities have included the development or investigation of various welding processes, the development of electrodes and fluxes for welding, welding metallurgy and weldability, and the surfacing of large components. This institute is quite active in the study of electroslag welding, a development studied initially here rather than at the Paton Institute. Considerable research on the welding and fracture mechanics of gas line pipe is currently underway at the Welding Institute. The facility has also conducted extensive studies on the creep, fatigue, and brittle fracture of weldments and base metals.

A significant amount of research on the corrosion of low-alloy steels, stainless steels, and aluminum alloys is undertaken. Past research has involved the study of pitting and stress corrosion cracking of stainless steels and the atmospheric attack and stress corrosion cracking of low-alloy steels. Liquid metal corrosion studies have also been undertaken, but the extent of the research has not been large, suggesting that the Czechoslovaks are not engaged in a strong effort to develop fast-breeder nuclear reactors.

Extensive research in nuclear metallurgy has not been observed, although the Lenin (Skoda) Steel Works has researched pressure vessel alloys and fabrication techniques for reactor vessels in pressurized water reactors. The Czechoslovaks do not have a strong independent nuclear power program, but they are cooperating with the U.S.S.R. and other CEMA members in nuclear power reactor development. Czechoslovakia is to supply some of the conventional components for the four nuclear power reactors being supplied to Czechoslovakia by the U.S.S.R. and is supplying components for other Soviet power reactors.

The research program on nonferrous metallurgy is much more limited than that in ferrous metallurgy. The bulk of the effort has been directed toward mineral benefication and the refining of aluminum and copper. Some alloy research has been done on aluminum and on magnesium, and appreciable research on titanium and its alloys was done in the past. Over the last few years, efforts in titanium have dwindled significantly.

The amount of fundamental research has continued to increase over the past 3 years, and excellent work on crystal growth, atomic structure, defect structures (dislocations and stacking faults), magnetic and electronic properties, creep, and fatigue have been conducted. Extensive research in the fundamentals of creep and the effect of dislocations on creep in various alloy systems has been conducted by J. Cadek of CSAV's Physics of Metals Institute at Brno. Similarly, excellent work on the role of dislocation movements in the three stages of fatigue has been carried out by Petr Lucas of the Institute of Metallurgy. Recently, there has been considerable emphasis in combining the results of such creep and fatigue studies to obtain an improved understanding of fatigue and creep interaction and in developing improved damage criteria, a subject upon which many millions of dollars will be spent in the coming decade in the United States. This topic is extremely important to fast-breeder reactor technology and to high-temperature petrochemical processing.

b. Physics and mathematics (S)

Research in fundamental physics appears to be somewhat stagnant in Czechoslovakia. Most of the specialists who have gained national and international reputations over the years appear to be continuing their old research activities, doing routine investigations and conducting other physics research that should be classified as applied in nature. Approximately one-half of the research in physics is being devoted to solid-state investigations. Research in the broad field of optics, which include electrooptics, spectroscopy, and interferometry, absorbs about 20% of the physics research efforts. Nuclear physics in both

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polymer properties, and hydrophilic polymers, which are of interest for contact lenses.

Increasing emphasis has been placed on biochemistry. The Institute of Organic Chemistry and Biochemistry has a large group working on nucleic acids, amino acid sequence of proteins, effects of antibiotics, protein synthesis, and enzymes. Charles University is active in research on hormones, acetylcholinesterase (enzyme) activity and lipid histochemistry.

Significant work is done in several areas of physical chemistry in addition to the previously mentioned work in physical organic chemistry. The Mass Spectrometry Laboratory of the CSAV Institute of Physical Chemistry is investigating the kinetics and mechanism of diazo coupling, which is of interest in connection with azo dyes. The Jaroslav Heyrovsky Institute of Physical Chemistry and the associated Heyrovsky Institute of Polarography are active in research on polarography, electrochemical reactions, fuel cells, and reaction kinetics. The major universities conduct research in physical chemistry.

Important research is done at several facilities in inorganic and analytical chemistry. Outstanding work on the chemistry of scandium, gallium, lanthanum, and other rare earth elements has been carried out by Frantisek Petru at the College of Chemical Technology, Prague. The chemistry of copper complexes has been studied at the Slovak Technical University. Good research on instrumental methods of analysis is done at Charles University, Comenius University, the College of Chemical Technology, and the Heyrovsky institutes. The Nuclear Research Institute at Rez is concerned with analytical and inorganic chemical problems related to the processing of nuclear fuels and with radiochemical reactions, plutonium chemistry, fluorine chemistry, and the properties of uranium compounds.

The Institute of Inorganic Synthesis, also known as the Laboratory for Special Inorganic Chemistry, Rez, has done extensive research on the chemistry of metal and boron hydrides. During 1960-65 this institute cooperated with the U.S.S.R. in a research program directed toward the use of boron hydrides, such as pentaborane and decaborane, and hydrazine monoborane as components of liquid rocket fuels. The staff of this institute is continuing to do outstanding research on the chemical and physical properties of hydrides, but the current work does not appear to involve military applications.

The geographic area in which Czechoslovakia is located has long been noted for its capabilities in metals production and metallurgical technology. This history extends back to the 19th century. Despite being overrun in two World Wars, conquered by both the Germans and the Russians and presently under political domination by the Soviets, the capabilities of the Czechoslovaks in metallurgical technology have continued to expand. Yet Czechoslovakia is a landlocked country that does not have the native resources to support a complete metallurgical industry. Nevertheless, from the standpoint of metallurgical technology and innovation, Czechoslovakia ranks well above the other Soviet bloc countries such as Poland and East Germany. In some areas of technology, the Czechoslovaks rival the Soviets.

The metallurgical research and development program is of high quality and well funded, but it is concerned primarily with the metallurgical products of economic importance to the country. As a consequence, the research is directed principally toward improving processes for producing steel products and toward improving the quality of the metal products produced. Considerable research is directed also toward refining native nonferrous ores, particularly copper ores.

Metallurgical research and development programs are undertaken at government laboratories under both the Ministry of Metallurgy and Engineering and the CSAV as well as at plant laboratories. Some metallurgical research is also conducted at universities and technical colleges, but the research at such educational facilities is far less impressive than that done at the government and plant research laboratories. In contrast to the other Communist countries, extensive metallurgical research is done in plant research laboratories, such as those connected with the Lenin (Skoda) Steel Works in Plzen, the Klement Gottwald Steel Works in Ostrava, and the Vitkovice Steel Works. Such work at the plant facilities has been applied and directed chiefly toward the improvement in processes and in product quality, although a significant amount of basic metallurgical research has also been undertaken in such facilities. Research at the CSAV facilities has been basic in nature while that at the Ministry of Metallurgy and Engineering's Research Institute of Ferrous Metallurgy in Prague has been more of the applied type. Research at universities has been fundamental in nature.

All areas of metallurgical technology important to the Czechoslovak economy are covered fully while those not important to the economy are not researched to any significant degree. Recent research on steel production has included ore benefication, briquetting and sintering, blast furnace reactions, the physical

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high and low energies is proceeding at a surprisingly low rate of effort amounting to only about 10% of the total effort. The remaining interests and activities involve plasma physics, quantum electronics, and acoustics.

The major portion of research in solid-state physics is divided between that being conducted at the laboratories of Charles University and the institute of the CSAV. The work being done at the university represents crystal studies on single crystals and crystalline structures in alloys. Primary interest involves the studies of stress variations and strain-rate changes. The most prominent investigator heading those studies is Dr. M. Saxlova. Other activities on a low level at Charles University involve studies of material mechanical properties, field theories, aluminum oxide-structures, X-ray diffraction of solids, cadmium-telluride rectifier characteristics, and electron correlations and susceptibility of glasses.

At the CSAV institutes in Prague and Brno, a considerable effort is devoted to lattice mechanics and the concepts leading to development of semiconductor devices. Although there are indications that some work is being done with germanium structures, silicon materials are being emphasized. This is shown by the research dealing with tunneling spectroscopy induced by local modes and measurements in In-SiO2 degenerated p-silicon junctions. Metal oxide semiconductor (MOS) structures are also being studied to determine the influence of surface treatment of silicon on the effective impurity charge density. The Czechoslovaks are also conducting a large amount of applied research in connection with semiconductor film structures. Recrystallization and crystal structures of evaporated films and thin film properties of metal and liquid films are being studied. Some good research is underway dealing with control of semiconductor-insulator interface characteristics in metal insulator conductor (MIS) systems. A limited amount of research associated with semiconductor materials is being pursued at the College of Chemical Technology at Pardubice which involves germanium-doped (Sb2Te3) crystals. The small amount of research being conducted in magnetics in Czechoslovakia indicates that the Soviets predominance in assignments of the Council for Economic Mutual Assistance is very effective.

Approximately one-half of the research being done in optics, electrooptics, photometry, spectroscopy, and interferometry occurs at the institutes of the CSAV. Investigations are concerned with the study of electrooptical properties of ferroelectrics from the standpoint of birefringence and temperature dependency. Work along this line is also underway in connection with stress-induced birefringence as related to phase transitions in potassium dihydrogen phosphate (KDP). Both radio-frequency and solid-state spectroscopy are receiving some attention at the CSAV—the first is being explored to develop instrumentation needed for measurement of electron nuclear double magnetic resonances and the second for development of particle spectrometers. Czechoslovak specialists in the application of spectroscopy appear to be skilled in the use of Auger spectroscopy in their studies of silicon surfaces. Research in photometry is at a low level and shows a casual interest in calibration and photoelectric receivers. The research in interferometry is industry-oriented and involves the use of lasers as a coherent source of light. A limited amount of research, which may be expanded later, is being conducted at the CSAV on optical information storage in potassium chloride and bromide crystals. This latter interest is connected with the development of holographic instruments and techniques.

Czechoslovakia appears to be deemphasizing basic research associated with the nuclear sciences. Since the institutes pursuing research in nuclear physics have undergone reorganization, their activities have been curtailed significantly. At the present time it appears that a limited amount of high-energy research remains under the CSAV, Charles University, and the P. J. Safarik University, Kosice. Much of the research deals with subjects concerning the operation of betatron and accelerator facilities. Some theoretical studies have been reported on pion-nucleon coupling analyses at the CSAV. Some work has been done on the study of noncentral effects of nucleon transfer functions at the CSAV, which indicates that some past work is being reviewed. Models are being formulated that deal with excitation functions and isomer ratios of kaon reactions, with some extension of the subject being carried into studying the interference effects in pionic decay of neutral kaons. At Safarikovo University, some contributions have been made in determining particle energies for collisions by using track visualization observed in photographic emulsions. Inelastic scattering by energy radiated from dysprosium isotopes of high-energy deuterons is a subject of research at Charles University. Research in the low-energy phases of nuclear physics is at a low level and generally deals with experimental studies in the use of research reactors.

The remaining sub-branches of physics, those which show very moderate interest and progress, involve magnetohydrodynamics (MHD) and plasma, physics

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superconductivity, quantum electronics, and acoustics. Most of the plasma and MHD work occurs at the institutes of the CSAV. The studies involve microwave energy absorption effects of pulses on inert gas plasma columns, transverse wave penetration into plasma, beam-plasma interactions, and plasma diagnostics. With regard to quantum electronics, the Technical University of Prague appears to have developed significant capabilities probably aimed at developing lasers for communications. At the present time, laser specialists are studying means for single-mode modulation by using acoustic waves. Others at the Technical University are studying frequency shift techniques which can lead to development of better means of frequency control. In acoustics, scattered efforts are indicated by the few studies reported on shock and detonation, vibrations, and oscillations. The central interest appears to be the state of real gases following primary and reflected shock waves and their structures.

Mathematical research is strong and is of good quality and of substantial quantity. The mathematical capabilities of the Czechoslovaks appear sufficiently strong so that they can be expected to continue to do well in this field. Their continued productivity in spite of social upheavals is also a good indicator of this prospect. The range of subjects treated is wide, with recent emphasis being placed on analysis (especially ordinary differential equations), logic (including graph theory), geometry, statistics, numerical methods, and applications (such as mathematical programing, information theory, and automatic control). The overall output of research may have slackened in recent years, but the output of mathematics applicable to other fields seems to be increasing. The Czechoslovakian performance of mathematics research is not much behind the outstanding performance in Hungary, but the emphasis is more toward applications.

Mathematical activity is centered in the universities and in the mathematics institutes of the CSAV, which publishes five journals oriented toward the subject. There is evidently a good effort toward maintaining communication with mathematicians throughout the world so that Czechoslovak research is often published in Western and Eastern Europe, the United States, and Asia.

Little recent information is available on computers in Czechoslovakia, but the frequency of papers on numercial analysis and applications indicates that computers are receiving substantial attention. They are being used for control of industrial processes. In many respects, computer software developed in the country is more advanced than that in the U.S.S.R. Currently Czechoslovak computers come from the United Kingdom, France, the U.S.S.R., and the United States. The U.S. computers are usually obtained through the United Kingdom and France, although some U.S. computer firms, for example, Hewlett-Packard and Uarian, are exporting directly to Czechoslovakia. Also, IBM has a sizable share of the market.

c. Astrogeophysical sciences (C)

(1) *Astronomy*—Astronomical research is competent but generally is not outstanding. However, the country enjoys an international reputation in cometary and meteor astronomy, and except for the U.S.S.R., it is the leading East European country in solar research. The science of astronomy enjoys a high standing with the general public, and there are about 50 public observatories and several planetariums in Czechoslovakia. The Czechoslovak Astronomical Society, comprised of both amateur and professional astronomers, is a respected organization, and there is astronomical activity in several of the universities.

Professional research is guided by the Scientific Board of Astronomy, Geophysics, Geodesy, and Meteorology of the CSAV-SAV. One primary center of activity is the Astronomical Institute of the CSAV, Prague, which includes the Ondrejov Observatory, about 40 km. southeast of Prague. The second principal center is the Astronomical Institute of the SAV, Bratislava, and its Skalnate Pleso (Rocky Lake) Observatory on Lomnicky Stit. Both the Ondrejov and the Skalnate Pleso observatories are equipped for stellar, solar, and cometary and meteor astronomy. The largest instrument is a 2-meter reflecting telescope at Ondrejov, useful particularly for stellar spectroscopy. The Skalnate Pleso Observatory has a solar corona station on the summit of Lomnicky Stit. There is also a network of about 22 all-sky camera stations distributed throughout Czechoslovakia for determining the trajectories of large meteors and to aid in locating any resulting meteorites.

Astronomical research includes some theoretical cosmology and celestial mechanics and both theoretical and observational galactic and stellar astronomy. However, the principal areas are cometary and meteor astronomy and solar research, in which both the Ondrejov and Skalnate Pleso observatories engage. Theoretical studies and optical and radio observations are made. In the solar area, the major effort is at Ondrejov, where emphasis is on the study of solar flares in which there is cooperation with the U.S.S.R. and the West. There has also been a

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Czechoslovak Commission on Solar-Terrestrial Physics, and studies in this area, as well as on other aspects of solar research, are conducted by the Geophysical Institute of the CSAV, Prague, and by that of the SAV, Hurbanovo.

(2) *Space science and aeronomy*—Since the beginning of space activity, the space science effort has been directed principally to satellite tracking. The country participates in the Soviet-sponsored INTEROBS optical tracking program for the determination of short-period changes in upper atmospheric density and in various Soviet- or Western-sponsored photographic tracking programs. The Ondrejov Observatory has cooperated also with the U.S.S.R. in making photometric observations of satellites, including the study of atmospheric optical properties and aerosol and ozone distributions.

Czechoslovakia is one of the principal participants in the Soviet-sponsored Intercosmos cooperative space program of the East European Communist countries. It has provided some of the instrumentation for, or otherwise has participated in experiments involving, several of the Soviet-launched satellites of the Intercosmos series. These vehicles, the first of which, Interkosmos-1, was launched in October 1969, have had various missions, including solar, cosmic ray, magnetospheric, and ionospheric research. A recent contribution by Czechoslovakia was the provision of some of the instrumentation for Interkosmos-8 launched in December 1972 to make ionospheric observations. Czechoslovakia also participated in the cooperative solar and ionospheric experiments conducted by means of the high-altitude geophysical rockets Vertikal-1 and Vertikal-2, launched by the Soviets in 1970 and 1971, respectively. In addition, it has cooperated in developing instrumentation for Soviet meteorological satellites and is a party to a 1971 agreement by the East European Communist countries to establish the Soviet-sponsored communications satellite system.

Czechoslovak research in the disciplines relating to the high atmosphere is competent but not internationally prominent. Cosmic ray observational activity is centered in the Institute of Experimental Physics, Kosice, of the SAV. It has a cosmic ray laboratory on Lomnicky Stit and has cooperated with the U.S.S.R. in making observations in Antarctica. The principal center for ground-based ionospheric research is the Geophysical Institute of the CSAV, Prague, which has ionospheric observatories at Pruhonic and at Panska Ves. Research includes the making of vertical incidence soundings, investigations of ionospheric structure, and radio-wave propagation research. The Upper Atmosphere Department, Prague, of the Astronomical Institute of the CSAV conducts airglow research and is active in twilight-sky studies of the aerosol content of the upper atmosphere. Ground-based photometric observations are made at the Ondrejov and Skalnate Pleso observatories, and twilight sky measurements have been made from aircraft and from stratospheric balloons in cooperation with the French.

(3) *Meteorology*—Meteorological research in Czechoslovakia is not outstanding. That conducted by the Hydrometeorological Institute, which is headquartered in Prague, is predominantly in climatology and synoptic meteorology. Similar type research is done also by the Institute of Meteorology and Climatology, Bratislava, of the SAV, and in the universities. The Hydrometeorological Institute has also done a small amount of numerical forecasting research. The Institute of Physics of the Atmosphere, Czechoslovak Academy of Sciences, is located in Sporilov. The institute conducts research on general circulation of the atmosphere and also conducts studies in dynamic climatology, physics of the clouds, and precipitation and the boundary layer of the atmosphere. Czechoslovakia is one of the three countries in Europe with the greatest air pollution. Atmospheric physics research is playing an important role in improving the dissipation of smoke stack gases caused by a sprawling power engineering, metallurgical, and chemical industry.

(4) *Terrestrial geophysics and geology*—Czechoslovakia exhibits a high level of competence in terrestrial geophysics, particularly in seismology. The most important center is the Geophysical Institute, Prague, of the CSAV. Other principal centers are the Geophysical Institute of Charles University; a center of the SAV, Hurbanovo; and the Institute of Applied Geophysics, Brno. Czechoslovakia has major geomagnetic observatories at Pruhonice, Budkov, and Hurbanovo, and a seismograph network with instruments at Pruhonice, Prague, Kasperske Hory, Bratislava, Srobarova, Hurbanovo, and Skalnate Pleso. In addition to the network station, there is an experimental subterranean station at Kasperske Hory.

In research on geomagnetism, the study of solar influences on the geomagnetic field is emphasized. However, work is done also on geomagnetic pulsations, in making aeromagnetic surveys and preparing geomagnetic maps, and in paleomagnetism. Magnetotelluric (earth) current observations have also been made in studies of the deep geological structure in Czechoslovakia.

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Seismologists of the Geophysical Institute of the CSAV are doing significant research on the seismicity of Europe and the classification of European earthquakes. They have made major contributions to the European Seismological Commission with regard to these topics, including cooperation with other East European countries in the deep seismic sounding of the Carpathian-Balkan region. This institute also emphasizes the study of the propagation of seismic waves and is active in terrestrial heat flow research. Research in exploration geophysics, including deep-seismic sounding and ultrasonic well-logging, is conducted by the Institute of Applied Geophysics. Geophysical prospecting is done also by the Mining Research Institute, Prague, of the CSAV, and by other organizations.

Some scientific geological research is conducted by the Institute of Geology of the CSAV, Prague, and by that of the SAV, Bratislava. However, the Czechoslovak geological effort is directed primarily to mineral prospecting. This effort is coordinated by the Central Geological Institute, Prague, which is analogous to a national geological survey. The institute cooperates in this work with various other geological as well as geophysical and mining activities. It is engaged in a long-range program to explore the deep geological structure of the north rim of the Alps and of the Carpathians. In addition to the search for minerals, this effort is directed to locating potential subterranean heat sources. Plans for the development of geology in Czechoslovakia until 1980 have been prepared also under the auspices of the Central Geological Institute.

(5) *Geodesy*—Geodetic research capabilities in Czechoslovakia are slightly behind those of Hungary and East Germany and are considerably behind those of the leading countries of Western Europe and the U.S.S.R. The Research Institute for Geodesy, Topography, and Cartography, Prague, the most modern and best equipped geodetic facility in the nation, is the leading center for both theoretical and applied geodetic research. Geodetic studies are geared primarily toward applied research and have covered many fields of geodetic triangulation and leveling. New first- through fourth-order triangulation and the unified leveling networks have been completed. Research and experimental studies have included the problems of measuring errors, the determination of related elevations in mountainous regions, and recent movements of the earth's crust.

As a member of the East European Sub-Commission for Satellite Geodesy, Czechoslovakia participates in geodetic observations and studies based on these observations. The country has assisted the United States and France with their geodetic satellite programs and is participating currently in the dynamics program and the International Satellite Geodesy Experiment. Research activity has focused on the adjustment of spatial satellite nets, the determination of the shape and dimensions of the earth from satellite and terrestrial data, and the reduction of satellite observations.

Activity in geodetic astronomy has led to the development of a new method of comparing clocks with microsecond accuracy using image synchronization impulses of television transmissions. Czechoslovakia's 5-year plan (1971-75) calls for the determination and solution of problems of latitude for geodetic and astronomic purposes.

Gravimetric studies have included the downward continuation of gravity to a reference surface, satellite orbit computations using gravity anomalies, fundamental gravity parameters of the earth's figure, and the structure of the earth's gravity field derived from satellite data. Problems concerning tidal observations and systematic observations of earth tides below the surface of the earth also have received considerable attention.

Dr. Milan Bursa is probably the best known geodesist in the European Communist countries. His contributions include the determination of the Czechoslovak ellipsoid and research in using satellite geodesy to determine the figure of the earth, both independently and combined with classical methods. Bursa works closely with Dr. L. P. Pellinen, a leading Soviet scientist who investigates the combined use of gravity and satellite data.

(6) *Hydrology and hydraulics*—Czechoslovakia is one of the leading East European Communist countries in hydrologic and hydraulic research. The research is predominantly of an applied nature and is directed toward full utilization and control of water resources for hydroelectric energy, irrigation, domestic and industrial water supplies, improvement of inland waterways, and flood control. The principal organizations conducting this type of research are the Institute for Hydrodynamics of the CSAV in Prague, the Hydrologic and Hydraulic Institute of the Slovak Academy of Sciences in Bratislava, and the Research Institute of Water Economy in Prague.

Research in hydrology is directed toward the problems of determining precipitation-runoff relationships, long-term discharge forecasts, flood control, dynamics of suspended and transported

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sediments, ground-water flow characteristics through various media, hydrokinetic problems encountered in removal of radioactive substances from wastes of uranium processing, and methods of pollution control. In hydraulic research, efforts are concentrated on flow turbulence; design of shaft spillways, stilling basins, and gates; load pressures on locking installations; vibration and cavitation effects on turbines; and construction of pilot plants for water treatment and pollution control. There is an increasing use of numerical and analog computers for handling problems of water resources and economy. Czechoslovak engineers have been successful in devising methods and instruments for measuring snow density by radioactive emission; detecting leakage through a dam by salt tracers; and plotting water-stage, discharge, and velocity hydrographs.

Czechoslovak hydrologists and hydraulic engineers are very active in national and international professional organizations and meetings. Some of the professional engineers have served as consultants on hydrologic and hydraulic problems in several less-developed countries.

(7) *Oceanography*—Land-locked Czechoslovakia has no significant oceanographic capability; however, some oceanographic work has been carried out. The most important marine science organization is the Biological Institute of the CSAV's Hydrobiological Department at Prague. It is conducting studies on plankton, bottom ecology, and chemistry of the Black Sea. In additon, Charles University is doing some work in geological oceanography.

Czechoslovakia has not been active in international oceanographic organizations. It cooperated, however, with Cuba in Caribe Uno, an undersea habitat experiment, which took place from 17 to 20 July 1966 off the Cuban coast near Havana. A later experiment has not been reported. The cylindrical habitat, carrying two scientists, was designed and built in Czechoslovakia. The goal of this experiment was investigation of biological effects of prolonged submergence on man.

Glossary (u/ou)

ABBREVIATION	FOREIGN	ENGLISH
CSAV.....	*Ceskoslovenska Akademie Ved*.....	Czechoslovak Academy of Sciences
IUGG.....	*Mezinarodni Unie Geodezie a Geofyziky*..	International Union Geology and Geophysics
SAV.....	*Slovenska Akademia Viet*.....	Slovak Academy of Sciences
VSLU.....	*Vyskumny c Skusobny Letecky Ustav*.....	Aeronautical Research and Testing Institute
LVU.....	*Letecky Vyzumny Ustav*.....	Aviation Research Institute
VUMS.....	*Vyzkumny Ustav Matematickych Stroju Mezinarodni*	Research Institute of Mathematical Machines

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