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Italy

December 1973

Science

NATIONAL INTELLIGENCE SURVEY

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NATIONAL INTELLIGENCE SURVEY PUBLICATIONS

The basic unit of the NIS is the *General Survey*, which is now published in a bound-by-chapter format so that topics of greater perishability can be updated on an individual basis. These chapters—Country Profile, The Society, Government and Politics, The Economy, Military Geography, Transportation and Telecommunications, Armed Forces, Science, and Intelligence and Security, provide the primary NIS coverage. Some chapters, particularly Science and Intelligence and Security, that are not pertinent to all countries, are produced selectively. For small countries requiring only minimal NIS treatment, the *General Survey* coverage may be bound into one volume.

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Although detailed sections on many topics were part of the NIS Program, production of these sections has been phased out. Those previously produced will continue to be available as long as the major portion of the study is considered valid.

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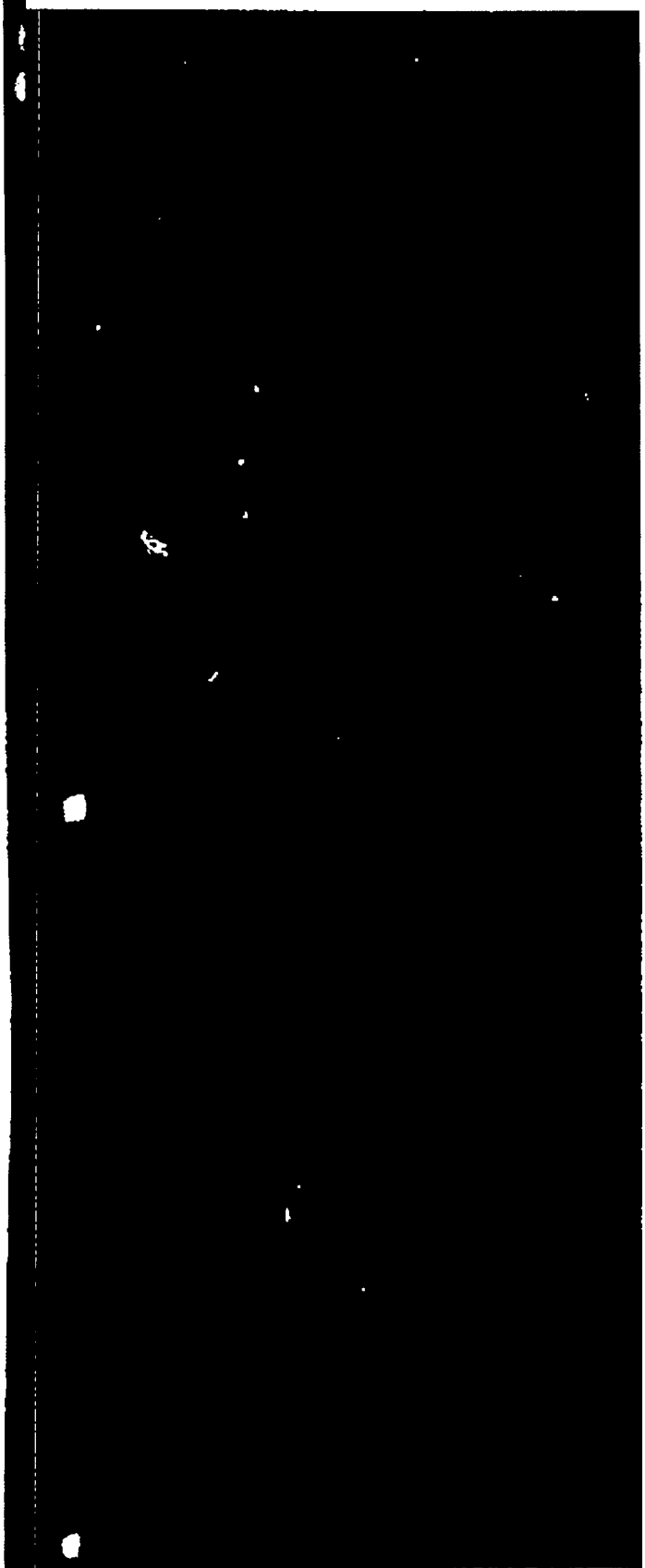

ITALY

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This chapter supersedes the scientific coverage in the General Survey dated October 1959.

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FIGURES

Science

A. General ~~(S)~~

The birthplace of modern science, Italy has a strong scientific tradition that can be traced back to the Renaissance. The outstanding achievements during the 16th through 19th centuries of famous men such as Galileo, Torricelli, Galvani, Volta, and Avogadro are a matter of record. And the city-states of Rome, Florence, and Naples became the seats of academies of science more than three centuries ago. During the 20th century, there have been numerous distinguished Italian scientists, including Guglielmo Marconi, a Nobel Prize winner in 1909, who served as the first president of the National Research Council (CNR) after it was founded in 1923. Other Nobel winners were Enrico Fermi in 1938 and Giulio Natta in 1963.

Italians have made important contributions in science, including chemistry, nuclear physics, electronics, and medicine during the past 50 years, but Italy has not maintained its much earlier position of leadership in science generally. During the Mussolini era following World War I, scientific activity was diverted toward military applications. This redirection of activity, emigration of many gifted young scientists, including Fermi, to the United States, and World War II damage and disruption wiped out much of the national research and development capability. The rebuilding process has been slow, and today among the Western European countries Italy is outranked in scientific capabilities by the United Kingdom, West Germany, France, Sweden, and the Netherlands. It has been estimated that the country is spending less than 0.9% of its gross national product for research and development. There are several factors contributing to the relatively slow progress of science in Italy: The lack of natural resources—particularly coal, petroleum, and metal ores—has retarded applied research and engineering, the impact of the war—considerable loss of the younger and stronger scientific and technical personnel and extensive damage to research facilities—still remains, and although industrial growth has been outstanding during the postwar period and research funding has expanded rapidly, the pace has not been rapid enough for Italy to catch up with other highly industrialized countries. Moreover, despite its remarkable industrial growth in the last decade or so, Italy is making a slow transition from scientific discoveries to operational applications.

Another restraining factor on scientific and technological research is the general chronic instability of the Italian political situation, which has led to long delays in the passage of appropriation bills for scientific activities. Also, none of the major reforms recommended by the president of the CNR (Professor Alessandro Faedo), such as reorganization of various agencies concerned with scientific research, higher pay for scientific staff, university reform, and strengthening of agricultural and industrial research, have been acted on. Although the slowdown of scientific progress has been most apparent since 1970, a trend toward disruption of research activities within various elements of the university institutes and departments, autonomous research centers, and those of the government actually began about 6 years ago.

Political issues have become paramount and groups of dissident research workers have become involved in sitdowns and demonstrations against the policies on science being practiced in all areas. Some of the most competent Italian science directors and project leaders have resigned in disgust and have maintained that it has become impossible to conduct serious research. For example, in late 1969 the Higher Institute of Health in Rome encountered interruptions by dissident workers and an outstanding number of the institute's physics department resigned. Also, Italy's first program of Ph.D.-level studies, at the International Institute of Genetics and Biophysics, Naples, was curtailed by the occupation of its building by leftwing researchers and technicians. Efforts to transfer the program to Rome met with political problems, and it has since been shelved and all funds returned to the sponsor, the U.S. National Science Foundation.

Successive Italian governments have recognized the importance of research in maintaining Italy's competitive position in world trade and have endeavored to overcome deficiencies in research planning and to correct weaknesses resulting from the lack of cooperation between scientists in government, industry, and education. The structure of the Italian research establishment is being modernized slowly in response to demands from scientific research workers and students. The United States is used as an example in reforming scientific research and scientific education. One of the problems facing reformers, however, is that the Italians have a long history of independent research and are strongly opposed to any kind of centralized control over their activities, although the need for more cooperation between economic and research planners is apparent. Private industry and state-owned industrial complexes conduct considerable research, but the companies are highly competitive and do not cooperate with each other in research programs.

The Italian Government has strongly supported international cooperation in scientific activities. In 1970, for example, about 13% of the government's research and development expenditures went to international organizations, especially those with research facilities in Italy. Some of the international organizations in which the country has been active concern space, missile, nuclear, and electronics research. The European Atomic Energy Community (Euratom) Joint Nuclear Research Center at Ispra employs about 1,000 persons involved in reactor physics, chemistry, and engineering. Italy is also active in the International Atomic Energy Agency (IAEA), the European Space Research Organization (ESRO), the European Launcher Development Organization (ELDO), the European Telecommunications Satellite Conference (CETS), and the International Union of Geodesy and Geophysics (IUGG). The country is also active in international oceanographic organizations such as the International Association of Physical Oceanography, the International Association for the Scientific Exploration of the Mediterranean, and the International Hydrographic Bureau. Italy is the location of the Antisubmarine Warfare Research Center of NATO, La Spezia; the IAEA's International Center for Theoretical Physics, Trieste; ESRO's European Space Research Institute (ESRIN), near Rome; and the International Computation Center of the United Nations, Rome.

Italian scientists are active participants in international scientific meetings and many such meetings are held in Italy, usually in Rome. Although the Italians welcome possibilities for conducting continued and new activities at international research centers in their country, they have become increasingly disillusioned with Euratom, ELDO, and ESRO because these organizations fail to provide programs of greatest interest to them, such as that on a fast neutron breeder reactor in the Euratom program and that on the experimental microwave satellite in the space program. They have shown little interest and enthusiasm for the organic liquid cooled reactor that became a major activity at the Ispra center. Professor E. Amaldi, one of the strongest champions of the European Nuclear Research Center (CERN), Geneva, has shown his preference for a site near Trieste for the 300 GeV accelerator, the largest on earth, which has been planned for some time by CERN. Italy's leading biologist, Professor Buzzati-Traverso, has been working for years to have the European Molecular Biology Organization (EMBO) located in Italy. It appears that neither situation will be resolved favorably to the Italians. The current crises in Italy's European cooperation in the atomic energy field through Euratom and in space through ELDO and ESRO appear to have had severe repercussions on Italian science policy.

Through the CNR, Italy has bilateral agreements in science and technology with the United States, the U.S.S.R., Bulgaria, France, the Netherlands, Poland, Romania, and Spain. Other bilateral agreements are in effect through the Italian National Committee for Nuclear Energy (CNEN). Italian officials involved in scientific affairs place great importance on scientific and technological cooperation with the United States, and Italy and the United States have cooperated for many years in space studies. In addition to the formal

programs of cooperation, there is a continuous contact between U.S. and Italian scientists in the universities and in industry, and there is an extensive student exchange program under various fellowship arrangements.

It was reported in March 1972 that scientific relations between the Italian CNR and the U.S.S.R. Academy of Sciences have deteriorated because Italian scientists were frequently unable to obtain admission to certain scientific institutes to which admission had been previously promised by the Soviets. Consequently, the CNR is not encouraging exchanges of scientific visits unless there is a specific agreement on the itinerary. There is no longer an exchange of space scientists between Italy and the U.S.S.R.

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

Governmental organizations are assuming increasing importance in the conduct of research and development in Italy. The principal government agencies concerned with research are shown in Figure 1. The highest authority for overseeing scientific research and development activities is the Interministerial Committee for Economic Planning (CIPE). Since February 1967, CIPE, which is chaired by the Prime Minister and composed of most of the important ministers, has been responsible for the control, organization, and planning of scientific research. Each year the president of the CNR submits to CIPE a report that is used as a basis for deciding on the research and development budget allocations by the government. Before submission, this study (General Report on the State of Science and Technology) is reviewed by the Minister of Science and Technology, who then passes his comments to CIPE. In December 1971, CIPE was given responsibility for the overall direction of CNEN's nuclear research activities and for approval of long-range plans submitted to it by CNEN through the Ministry of Industry and Commerce.

The Ministry of Science and Technology, formed in 1962, has practically no staff and has very limited funds. The minister has had an advisory function only. To date, most of the ministry's activities have consisted of studying ways of enlarging the responsibilities of the minister and in attempting to obtain the necessary powers for the ministry. The supporters of the ministry favor a system whereby detailed proposals for research programs must be

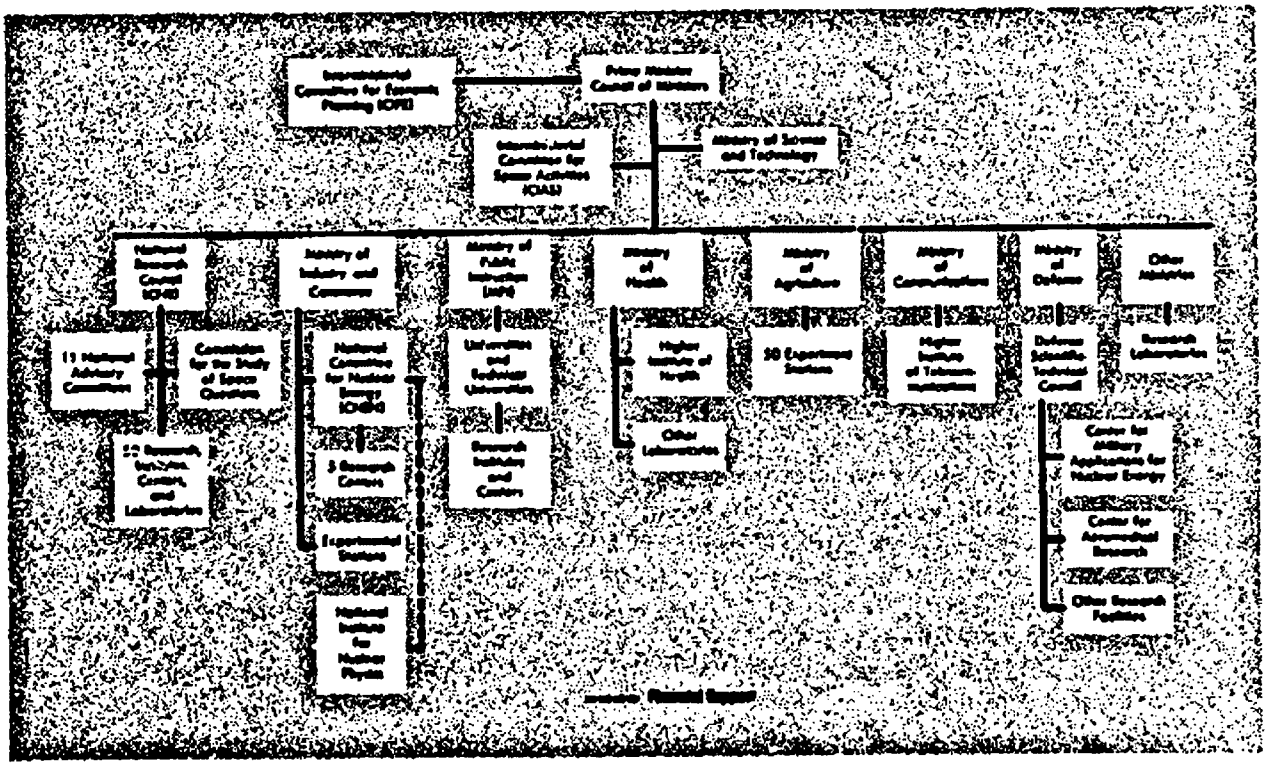

FIGURE 1. Government organization for science and technology, 1972 (U/OU)

submitted before funds are made available instead of the present system where funds are granted to universities and are often used by the universities as general subsidies. However, many professors in parliament have resisted any challenge to their control of research funds. Proposals for increasing the power of this ministry have also met with opposition from the Ministry of Public Instruction and from the CNR. The president of CNR believes that strengthening of the Ministry of Science and Technology would place a bureaucratic barrier between CNR and CIPE, from which the CNR obtains support for its program and budget. In September 1971 the Minister of Science and Technology became chairman of the Interministerial Committee for Space Activities (CIAS), which is to control policy and make major decisions regarding the Italian space program.

The National Research Council, which is under the Council of Ministers, has primary responsibility for most types of scientific research, and its president is generally recognized as the spokesman for the government scientific establishment (including the universities) in all fields except nuclear research. The CNR supports its own facilities, consisting of about 30 institutes, centers, and laboratories, and promotes science through grants to groups or centers at university research institutes and independent research institutes. The CNR plans and finances major programs, most of them of an interdisciplinary nature. The CNR has 11 national advisory committees covering various fields of science, engineering, and the social sciences. The CNR president is generally chosen from among the university professors, who constitute the majority of the 140 members of the advisory committees and is appointed by the President of Italy. Although the CNR is responsible for coordinating national science policy, it has limited powers to implement its decisions. It does not have control over the important ministerial laboratories, the nuclear energy program, or the space program. The CNR Committee on Space has only advisory functions. The CNR is second after the Ministry of Public Instruction as a spender of government funds for research and development, accounting for about 21% of the total in 1970, but most of the CNR funds are consumed as grants to university research so that its own laboratories are short of funds. The CNR grants research fellowships in Italy or abroad, provides funds for conducting scientific meetings and conferences, and negotiates bilateral science cooperation agreements with other countries. The CNR is attempting to promote closer collaboration in research between different industrial companies through strengthening of its technological research programs. The CNR administers the National Center for Scientific and Technical Documentation in Rome.

Many of the government ministries play important roles in the national research program by administering or supporting scientific research in facilities that are directly or indirectly under their control. Although the universities enjoy considerable autonomy, the Ministry of Public Instruction, which is the leading spender of government funds for research and development (32% of the total in 1970), exercises a considerable influence. The ministry provides funds for the construction of new laboratory facilities at the universities and for the purchase of apparatus and equipment for research. It also provides funds for the maintenance of research facilities at the approximately 2,100 research institutes, centers, and laboratories connected with the universities. More research is undertaken in the universities than elsewhere since the scientific institutes attached to them form the basic infrastructure of public research in Italy. The statutes and rules governing universities and university institutes are based on the premise that research is a complement to teaching. The present statutes determine the number of faculties and set the basic disciplines and the rules. Each institute is directed by the holder of a chair who deals with the administration and supervises the scientific work, but the institutes have no financial autonomy. Thus, the director of an institute has no authority to develop his research center. Generally he has too few research workers on his staff and even fewer technicians and junior staff. Of the total number of institutes, 875 are dependent on 93 scientific and technical faculties, 610 on 23 faculties of medicine and surgery, and 615 are under the 100 faculties of economics and human sciences. Several opinions have been expressed that the number of institutes is excessive and has resulted in duplication of effort. Sometimes there are more institutes than professors.

Substantial research programs are conducted by specific ministries. The Ministry of Health operates the Higher Institute of Health in Rome, which employs a staff of about 800 research personnel conducting research in biosciences as well as air and water pollution. The Ministry of Agriculture and Forests has increased its budget during recent years in order to modernize and expand its approximately 50 experiment stations. The Ministry of Defense has several laboratories subordinate to it, including the Center for Military Applications for Nuclear Energy, the Center for Aeromedical Research of the Air Force in Rome, as well as other research facilities. The

Defense Scientific-Technical Council coordinates research of interest to national defense.

The CNEN operates under the Ministry of Industry and Commerce but is largely autonomous. The CNEN, according to directives issued by CIPE, is specifically charged with promoting and conducting research on the peaceful applications of nuclear energy and is responsible for coordination of basic and applied nuclear and some nonnuclear research, prospecting for uranium, treatment of raw materials, the production of special and radioactive materials, and coordination of research in physics, chemistry, mathematics, biology, medicine, and engineering as they relate to nuclear energy. The CNEN is required to provide scientific and technical supervision of all projects concerned with production of nuclear raw materials and with production of nuclear energy. However, the nuclear power reactor program, which is of great importance to Italy because of the lack of coal and petroleum, was transferred in 1964 to the newly formed National Electric Power Agency (ENEL). As a result of this change, the CNEN, which prior to 1962 held first place in the amount of research and development funds assigned to government agencies, has dropped to third place. During 1970, CNEN accounted for 16% of the government research and development funds. Most of the CNEN budget is used for support of five larger centers of its own. In addition to the Trisaia Center, other centers are at Casaccia, Frascati, Bologna, and Saluggia. CNEN also had been the principal supporter of the National Institute for Nuclear Physics (INFN) in Rome, but this institute is now completely independent and its appropriations are approved directly by CIPE. The CNEN employs a staff of more than 3,500, about 70% of whom are graduates of higher institutions, research workers, and technical experts. The CNEN maintains technical and scientific relations with international and foreign organizations involved in nuclear research.

Space research until 1972 was under the control of the Space Research Institute. This was replaced by two new coordinating commissions: the CIAS, which is concerned with policy matters, and the Commission for the Study of Space Questions, which is under the CNR. Italian aerospace research and development efforts are managed and controlled by the Advisory Center for Studies and Research, which is directly under the Italian Air Staff.

Italy has many academies and professional societies which function as cultural associations concerned with the advancement of scientific research. Examples include the National Association of Science, the Italian Institute for Space Research, the Italian Physics Society, the National Association of Nuclear Engineering, and the Italian Forum for Nuclear Energy. Many of the societies make contributions by awarding financial grants for specific projects and by providing documentation services. They publish original papers of Italian scientists and provide translations of foreign scientific papers.

Italian industry occupies an important position in the overall picture, accounting for nearly one-half of the research and development activities. Research by private industry tends to be concentrated in a few large companies. The Italian automotive, chemical, electrical, pharmaceutical, textile, and tire industries have had strong research and development programs for many years. The smaller companies restrict their research to those activities which lead to immediate commercial results. The state-owned industrial firms account for about 20% of the industrial output and are among the leaders in industrial research.

Italian expenditures for research and development are increasing but are still inadequate when compared with other industrialized countries; the expenditures are low especially when compared with the amount expended by other highly developed countries of Western Europe. The total research expenditure for Italy, both public and private, for 1970 was estimated at about 0.8% of gross national product as against 0.7% in 1966. A committee appointed by the Minister of Science and Technology to advise on research and

FIGURE 2. Breakdown of Research Expenditures by Agency and Sector, 1970 ~~(U/OU)~~

	MILLIONS OF LIRE	U.S. DOLLARS*
Public Sector:		
Ministry of Public Instruction	74,332	118,931,200
National Research Council	50,000	80,000,000
National Committee for Nuclear Energy	37,024	59,238,400
Ministry of Health	4,417	7,067,200
Ministry of Defense	11,409	18,254,400
Ministry of Agriculture	6,026	9,641,600
Other Ministries	19,916	31,865,600
Contributions to international agencies	29,996	47,993,600
Total public sector	233,120	372,992,000
Industry sector:		
State subsidized industry	65,138	104,220,800
Private industry	185,203	296,340,800
Total industry sector	233,351	405,361,600
Total public and industry sectors	486,471	778,353,600

*Converted at the rate of 1 million lire = US$1,600.

development planning has recommended an increase in research and development funding by a factor of 4 by 1980. Figure 2 gives a breakdown of research expenditures by agencies and categories in 1970. The government supplied 48% of the funds, state-subsidized industry 14%, and private industry 38%. Government support of research varies widely from one discipline to another. About 93% of the $40 million spent on physics research during 1968 came from the government and only 7% from industry, while in chemistry, about 85% of $110 million came from industry sources and only 15% from the government. Most of the basic research in chemistry is funded in university institutes by the Ministry of Public Instruction, with substantial help from the funds assigned by the CNR to chemical research.

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

Ample opportunities for scientific education in Italy are available, particularly in the numerous state universities and in the two polytechnical institutes. There are 12 universities with both science and engineering faculties located at Bari, Bologna, Cagliari, Genoa, L'Aquila, Naples, Padova, Palermo, Pavia, Pisa, Rome, and Trieste. An additional 11 universities have a science faculty but no engineering faculty; the universities are situated in Camerino, Catania, Ferrara, Florence, Messina, Milan, Modena, Parma, Perugia, Sassari, and Siena. The two polytechnic institutes at Milan and Torino have engineering faculties only. All of the above are supported by the Ministry of Public Instruction. The private universities are not outstanding in scientific education. Among the more prominent higher educational institutions involved in scientific and technical education are the University of Rome with 5,500 students enrolled in the science faculty, Naples with 5,200, and Milan with 3,200. The University of Naples has the largest number (4,600) enrolled in the engineering faculty, while the Milan Polytechnic Institute has 4,300 in engineering and the Torino Polytechnic Institute has 3,000. In recent years, there has been a strong trend in Italy to cut back the study of law and to put more emphasis on the sciences and engineering. From 1962-63 to 1966-67, enrollments in the sciences more than doubled to 38,000 and, similarly, enrollments in engineering more than doubled to 52,100. Research facilities at many of the universities are old and overcrowded, although several of the schools in the northern industrial regions, particularly the two polytechnic institutes, have built additional facilities with the support of large industrial companies.

University education in Italy follows the Western European pattern with a curriculum prescribed by the Ministry of Public Instruction and with separate faculties in areas including, among others, medicine; engineering; mathematical, physical, and natural sciences (which include chemistry and biology); and agriculture. Graduation from any one of the faculties leads to the title of *dottore*. There has been considerable pressure for university reform from the students, but the parliament has been slow to act. Among the reforms suggested are the introduction of graduate degrees in research, the adoption of university departments as in universities in the United States, and the granting of greater autonomy to each university. Student disorders have been disruptive and caused the University of Rome to be closed for a time. Reforms in the elementary and middle schools have been made which have introduced modern methods of teaching science and have made the transition easier from middle schools to universities.

Italian scientists and engineers are generally well trained but often lack laboratory experience or specialized training. Educational authorities have sought to make university education more consonant with the needs of industry and technology. Engineering faculties have been reorganized, but in this area, universities cannot expand sufficiently to meet the demand. For the most part, Italian industry trains its own technicians and provides related training for newly employed university graduates. The large government-owned holding company, known as the National Hydrocarbons Authority, trains about 50 engineers each year, and Olivetti has a large training school at Ivrea for its researchers, technicians, and craftsmen.

A shortage of graduate students in Italy has existed because there were neither designated graduate schools nor organized programs of graduate study in the country. In the past, Italy has lost numerous scientists to other European countries and to the United States. According to a recent estimate, Italy has lost some 8,000 research scientists to other countries, principally the United States, in the past 20 years. Although these losses are lower than those suffered, for instance, by the United Kingdom, their effect appears to be far more serious because the Italian research establishment as a whole is proportionately much smaller. The government is studying ways to alleviate the conditions of insecurity

felt by the highly trained and highly competent scientists who tend to migrate.

Although the government has attempted to placate the concerns of the scientific sector, the turbulent political situation contributes little to ease the troubled atmosphere. Conditions in university research have improved during the past 10 years as a result of continuing support of research programs by the CNR and the increased research and development budget of the Ministry of Public Instruction. However, there are still many research workers in the less-favored classical disciplines who work at low salaries with inadequate facilities and equipment. A breakdown of the number of scientific and technical personnel engaged in research activities in the public sector and in the private sector in 1972 is given in Figure 3. Also given are the totals for 1969 and 1971. The general attitude of the government and the public toward scientists is favorable. Scientists enjoy high social and professional prestige and, especially in industry, are reasonably well rewarded financially. As a result, many competent young researchers are attracted to industry. University positions, on the other hand, are poorly paid except at the higher levels. University professors usually have outside positions that take time from university research. Efforts are being made to raise the levels of faculty salaries.

Italian research facilities vary considerably in quality. Many have modern equipment, but some are still using outmoded instruments which are inadequate to perform high quality research. The modern nuclear research facility at Ispra is an example of the high capital investment made by the Italians in the physical plant. However, the facility at Ispra lacked the manpower and operational funds to carry out effective programs and chose to turn the facility over to Euratom. Except for the University of Rome, most of the research institutes and laboratories of educational institutions lack up-to-date equipment and apparatus. The government has been aware of these shortcomings and provided in the 1969 budget the sum of $100 million for the purchase of scientific instruments and apparatus not available in Italy. The CNR has spent large sums from its budget to establish new centers in space research, atmospheric physics, and meteorology in Rome; desalination plants in Bari; and genetics and biophysics centers in Naples. Naples has the largest CNR center, the International Institute of Genetics and Biophysics. In addition, the Zoological Station in Naples is considered one of Europe's foremost centers for marine biology.

D. Major research fields

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

The Italian weapon research and development capability is limited presently to fighter aircraft, short-range tactical and antiship missiles, combat vehicles, and specialized subfields of research on ground

FIGURE 3. Scientific and Technical Personnel Engaged in Research Activities, 1972; Totals 1969, 1971 (U/OU)

BRANCH	RESEARCH WORKERS	GRADUATE TECHNICIANS	AUXILIARY WORKERS	TOTAL	TOTAL (1971)	TOTAL (1969)
Public Sector:						
State Administrations*	2,556	934	1,106	4,496	3,623	2,807
National Council of Scientific Research	1,359	674	738	2,771	2,358	1,459
National Nuclear Energy Board**	1,014	1,702	807	3,523	3,600	3,229
University	***16,802	1,870	7,606	28,278	28,318	20,229
National Electric Power Board	358	458	642	1,458	1,459	1,231
Subtotal	24,089	5,538	10,899	40,526	39,560	28,955
Private Sector:†						
Enterprises with state participation	2,645	4,113	1,610	8,368	6,307	6,012
Private enterprises	8,856	10,637	10,973	30,466	30,096	26,081
Subtotal	11,501	14,750	12,583	38,834	36,403	32,043
Total	35,590	20,288	23,482	79,360	73,963	60,998

*The figures indicate the total number of employees in research, even if not working full time.

**Administrative personnel are included.

***The figure includes all teaching personnel, except appointed professors.

†In the absence of data on personnel assigned to research in the private sector for the year in progress, provisional data from the Central Statistics Institute (ISTAT) is reported.

weapons and underwater ordnance. Italy depends primarily on the United States, the United Kingdom, Switzerland, France, and West Germany for new designs in weapons but conducts engineering improvement, in some instances, on the foreign materiel it receives. The nation's limited capability in weapon research and development is more a matter of policy than from any specific technological shortcoming. Neither the government nor industry has attempted to develop a strong, broad-base indigenous research and development capability in air, ground, and naval weapons. However, the nation has a high competence in the manufacturing aspects of weaponry, particularly that on aircraft, army tanks, and ground transportation vehicles. Through corporate mergers and complex consortia with companies in other Western countries, including the United States, the United Kingdom, France, and West Germany, the Italians are using their production expertise to good advantage, while benefiting from the weapons design and development know-how of the other nations.

Aeronautical research is conducted by the aircraft companies, the University of Rome, and the Polytechnic Institute of Milan. Inadequate funding and the lack of suitable test facilities limit the Italian research and development effort. The overall research effort in aeronautics is managed by the Advisory Center for Studies and Research. The Aerospace Research Center of the University of Rome, located at Urbe Airport near Rome, is engaged in research on problems of high-speed aerodynamics, gas dynamics, plasma physics, and various space-related technologies.

The two automobile firms Fiat and Alfa Romeo are the principal aircraft engine manufacturers. Fiat is Italy's largest and it has traditionally relied upon licensing agreements to manufacture General Electric and Rolls Royce engines. Licensed production underway at these two firms includes, among other products, the GE J79 engines for the Lockheed F-104 fighter, the GE J85 for the Fiat G91 fighter, and the T58 engines for the SH-3D and Agusta-Bell 204 helicopters being manufactured for the Italian Navy.

The Italian aerospace industry, with a work force of over 23,000 employees, is among the 10 largest in the world, about equal in size to the aerospace industries of Sweden or Japan. Although Italy has become one of the largest helicopter manufacturers in Europe, most of the aircraft produced are of U.S. design. Italy's research and development capability is moderately strong in small transports but weak in heavy transports, bomber aircraft, and advanced fighters.

Under government leadership, a new firm, Aeritalia, has been formed to consolidate the highly fragmented aerospace resources and capabilities of the country. To date, Aeritalia has absorbed the operations of the Aviation Division of Fiat, as well as a number of smaller enterprises. Fiat's Aviation Division has been involved in the production of the U.S.-designed Lockheed F-104 under license, and their own designed and developed G.91Y (Figure 1) fighter and G.222 transport aircraft (Figure 5). Other important development and production programs of Italian origin are the Macchi MB.326 jet trainer, light attack aircraft that are being exported widely, a variety of light civil and military aircraft, and helicopters. The largest designer and producer of helicopters is the Giovanni Agusta Aeronautical Construction Company, Inc. The AM-3 three-seat monoplane has been developed jointly by Aerfer Southern Aerospace Industry, Inc. (Aerfer) and Macchi Aeronautical

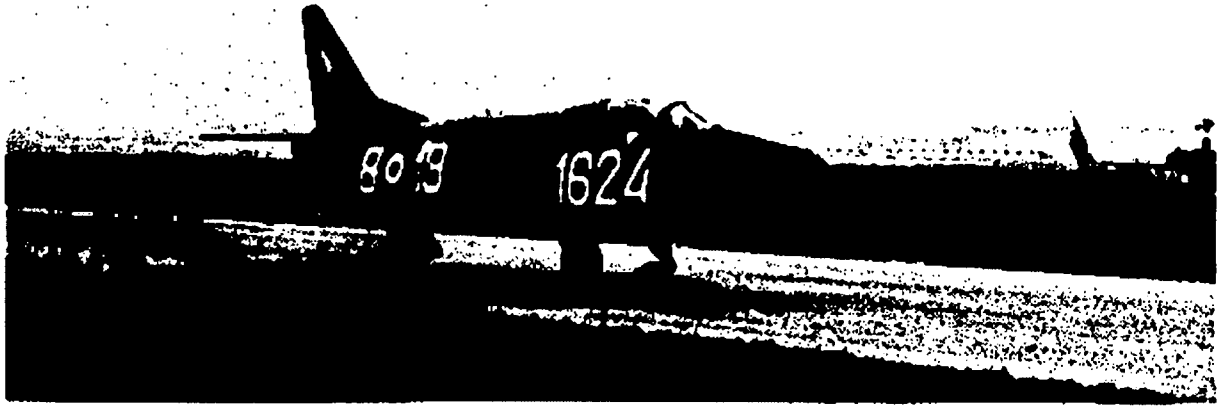

FIGURE 4. G. 91Y fighter aircraft (U/OU)

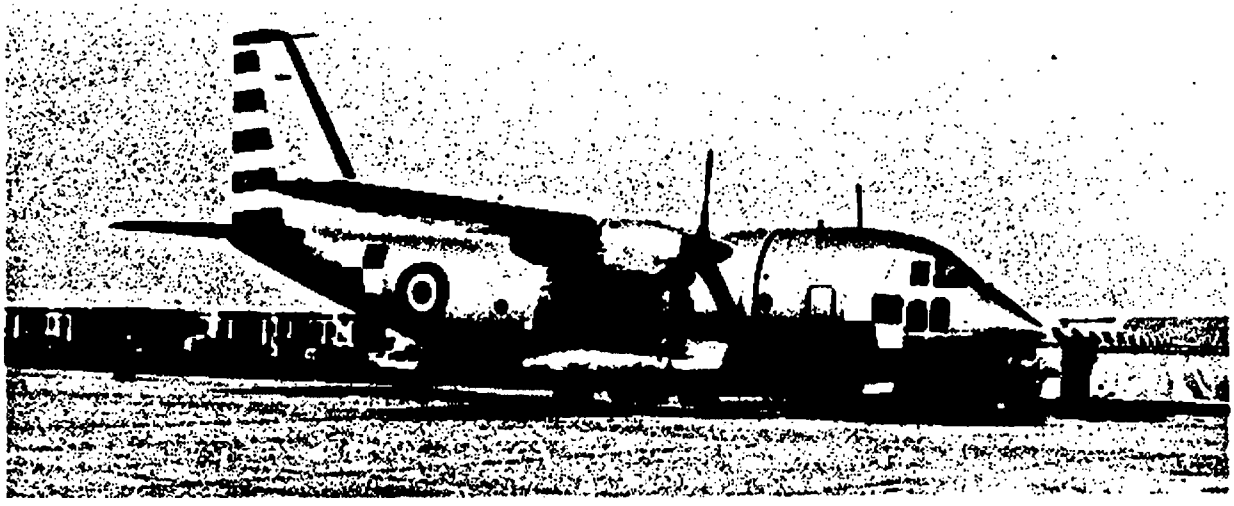

FIGURE 5. G. 222 transport (U/OU)

Company, Inc. (Aermacchi) Designed to meet an Italian Army requirement for a light aircraft, the AM-3 is suitable for such missions as forward air controller, observation, casualty evacuation, tactical support of ground forces, and general duties. Siai-Marchetti has developed the SM 1019A to perform similar missions.

Two other programs are emerging that will have major impact upon the industry from the later 1970's to the early 1980's. Both programs are being financed through the Italian Government and will be under Aeritalia management. Also, both are collaborative type programs—one with the United Kingdom and West Germany, the other with the United States. Under the terms of a tripartite agreement, Italian industry is to receive about 15% of the work involved in the development and production of a Multi-Role-Combat-Aircraft designated the MRCA-75. This will include contracts for electronic equipment and airframe sections. Current planning indicates one of the six prototype aircraft will be built in Italy. Deliveries of the MRCA-75 are scheduled to commence in the late 1970's. The second major program is between the U.S. Boeing company and Aeritalia. This program provides for the joint development of a STOL transport, with production to commence by the late 1970's.

The Italian missile research and development effort is expanding and now includes the design and development of naval (antiship) missiles, as well as field-force defensive and antitank missiles. The naval systems include the Sea Indigo and Spada surface-to-air, the Sea Killer Mk3, and the Otomat antiship cruise missiles. Of these, the Otomat program is the most noteworthy, and it represents a joint effort between Oto Melara in La Spezia and Matra of France. The field force systems are the Indigo surface-to-air and Sparviero antitank missiles. Production of the Indigo missile is currently limited to about 10 missiles every 3 months. The Italian Army reportedly plans to equip 100 firing batteries with this missile during the next 5-year period. The Sparviero antitank missile is expected to go into series production by 1975. At that time, it will probably be used as a replacement for the U.S. Tow antitank missile being bought for use by the Italian Army and now being produced under license in Italy and used by the Italian Army. Study efforts reportedly are underway on an unmanned 19-mm range surface-to-surface missile and various adaptations of the Sea Killer Mk1 (Nettuno) and Sea Killer Mk2 (Vulcano) antiship missiles. The Nettuno is a beam-riding solid propellant missile designed for use against destroyers and smaller vessels.

The Italians have invested heavily in the Fulcura Air Force Missile Test Range, Latina, near Anzio, and in the Salto di Quirra Test Range, Sardinia. These ranges have been used to test NATO systems and ESRO sounding rockets in addition to Italian missiles and rockets. Space associated research, as all other national-level research, is administered through the CNR. Following a reorganization in 1965, the CNR established the Inter-Committee Commission for the Study of Space Problems (CISP) to coordinate the national effort in the study of space (basic research) and the Space Activity Service (SAS) to manage the more applied aspects of space research and development. The SAS manages all activities involved in Italy's participation in the European Launcher Development Organization (ELDO), the European

Space Research Organization (ESRO), and the European Conference for Satellite Communications (ECSC).

Italy has conducted limited research and development on ground weapons. However, the expanded facilities and improved capabilities of Italian industry is enabling numerous projects to be undertaken in the research, development, and production of armored vehicles. Two such vehicles are currently in development, both of which are light weight and amphibious—one, the Fiat 6616 reconnaissance vehicle (Figure 6) is designed for a three-man crew, the other, the Fiat 6614 armored personnel carrier (Figure 7) is designed to carry 6 to 8 men plus the driver. A second version, the 6614P, is designed with a longer wheelbase to accommodate 12 combat-equipped men.

Italy was involved with France and West Germany in the determination of requirements for the Leopard-1 tank and later bought 200 Leopards from West Germany and will coproduce 600 more starting in 1974, but the extent of participation in actual research and development is unknown except that extensive testing of Leopard-1 (under hot climatic conditions) was conducted in Sardinia by the Italians. Considerable modification research and redesign also is conducted on U.S.-produced armored vehicles used by the Italian Army. Italian researchers have modernized the U.S. M-47 (Patton) tank. Firepower was increased by replacing the 90-mm gun with a 105-mm gun; other improvements included a new transmission, a modified hull, a new electrical system, a redesigned fuel system and ammunition storage arrangement, and a diesel engine. Also, an improved track link has been developed for the USA M-113 armored personnel carriers used in Italy.

FIGURE 6. Fiat 6616 Italian-developed lightweight amphibious reconnaissance vehicle (U/OU)

FIGURE 7. Fiat 6614 lightweight amphibious armored personnel carrier being developed by Italy (U/OU)

Italian work in mine warfare equipment is excellent, and commercial firms have extensive programs to develop and manufacture high-quality mines and mine fuzes for the Italian Army. Research and development on explosives and explosive phenomena are maintained at a level to provide for future defense requirements. Facilities are available for experiments with high-energy materials, and some work is done on the development of new and improved explosive compositions. Italy has a considerable capability for research and development of transport vehicles and their engines, but little effort is made with respect to military hardware. Fiat is the major producer of military vehicles. Research projects presently underway stress vehicle design for mountainous and rough terrain operations and amphibious capability.

The most significant bridging and stream-crossing equipment development currently underway is the Astra multispan tank-launched bridge; although launched bridges have been used, Italy has become the first country in the West to have successfully developed a multispan bridge. It consists of a scissors-type treadway span with the ramp section capable of being converted into a pier to serve as intermediate support. After the first span is emplaced, successive spans can be launched by other bridgelayers from the deck of the emplaced span.

Italy has a relatively strong research and development capability in topographic equipment. The development of the analytical plotter by OMI-Nistri in cooperation with the Bendix Corporation in the United States is a continuing project of considerable military interest. The Galileo works (*Officine Galileo*) has recently completed development of an orthophotographic attachment for a stereoplotter, a precision stereocomparator, and a new aerial mapping camera to add to its full line of photogrammetric and geodetic equipment. Research related to quartermaster equipment covers a variety of fields. Considerable work has been done on collapsible

containers, designed for both storage and transport of bulk liquid POL products, submersible and floating oil hoses, and fueling buoys for use in marine POL terminal systems. Italian work in direct energy conversion systems is limited, although some effort is underway on magnetohydrodynamics, especially closed-cycle systems.

The Italians have in the past or are now conducting research and development in all aspects of underwater ordnance, including antisubmarine warfare (ASW) mortars, torpedoes, and mines. Italy has long been a pioneer in these areas of development. The only known research and development being conducted in the field of torpedoes is directed toward a wire-guided torpedo carrier for the U.S.-supplied Mk 44 torpedo. Italy has had under development for many years an ASW mine designated T.A.R. A gun mount program has been established, and a number of private firms are participating in the development of modern dual-purpose, rapid-fire mounts. Naval fire control systems also are under development.

2. Biological and chemical warfare (C)

The Italians have a small biological and chemical warfare (BW/CW) research and development program directed essentially toward defensive aspects. Primary responsibility for initiating and coordinating BW and CW research and development efforts within the Italian Armed Forces rests with the Inspector General of Atomic, Biological, and Chemical (ABC) Defense. The Chief, Chemistry and Physics Technical Service, subordinate to the ABC Inspectorate, directs and administers the BW and CW research, testing, and equipment developmental activities of the Army Technical Center for Chemistry, Physics, and Biology (ATC), Rome. There are four laboratories at ATC: the chemistry and biology laboratories, both of which develop detection, rapid screening, and alarm techniques; a physics laboratory to support the first two; and a technological laboratory to develop end items.

Scientists engaged in BW- and CW-related fields of research are competent and benefit through an exchange of information on offensive and defensive advances in BW/CW through NATO, the Mutual Weapons Development Data Exchange Agreement with the United States, and FINABEL (France, United Kingdom, Italy, the Netherlands, West Germany, Belgium, and Luxembourg).

Known BW research is confined to defensive aspects, particularly detection and identification, but medical and health research provides knowledge applicable to all aspects of BW. Work at ATC has included studying the travel of aerosol clouds containing fluorescent particles, meteorological observations in various sections of the country, development of a sampling kit, and investigations of the fluorescent antibody staining technique for its potential role in BW agent detection. A contract has been awarded for research in methods of mass vaccination by aerosol.

Various civilian institutes and laboratories not currently connected directly with BW offer facilities that could be applied to BW programs if funding and directives were provided. For example, the Higher Institute of Health, Rome, has responsibilities for diagnostic work, and research is conducted on leptospirosis, Q-fever, arboviruses (presently the Bhanja virus is under study), air sampling techniques related to pollution, and on the epidemiology and diagnosis of microbial infections. Human and animal brucellosis are studied at the Institute of Hygiene of the University of Florence, Florence, and at the Veterinary Clinic of the University of Pisa, Pisa, respectively.

Scientists at the Serumtherapy and Vaccinogen Institute, Siena, prepared a detailed report on methods adopted for the titration of polyvalent snake venom antisera. Collected data were used to determine the toxicity of each venom and the neutralizing dose for the corresponding antisera. Although the natural poisons research is medically oriented, the data resulting from such work could lead to new sophisticated CW lethal and incapacitating agents. Research also is being conducted on neuromuscular blocking agents; quaternary ammonium salts were found to display cholinolytic properties similar to the standard U.S. incapacitating agent BZ. No information is available to indicate that Italy is engaged in studying new CW agents. Some basic research has been conducted, however, on known lethal agents, including the G- and V-type nerve agents for defensive purposes. This work is probably continuing. Italy's research on natural poisons is devoted primarily to plant alkaloids and snake venoms. Relatively little interest is shown in bacterial toxins.

A haversack kit has been devised for aidmen (NCO's) and battalion medical teams. It contains, among other first aid items, atropine automatic injectors and vials of 2-pyridine aldoxime methiodide (PAM) to combat nerve agent poisoning and amyl nitrite ampoules and antiraphenol for blood agent antidotes. The Italians have developed a refillable automatic atropine self-injector for self-aid against

nerve agent poisoning. Tests of this item, however, showed that the plastic spring housing tended to crack after only a few uses. Work on decontamination apparatus is limited to the evaluation of NATO equipment with adaptations or improvements to these items. Because emulsions adhere to surfaces, the Italians claim that the application of emulsions is effective for decontamination; for nerve agents, they have considered hydrate of aluminum silicate.

The Tirrena Incorporated Company, Rome, reportedly has developed a series of backpack flamethrowers. There is no information that any of these models have been standardized. The latest model, T-68, contains three 9-liter (2.4 gal.) steel tanks—two lateral tanks for fuel and a central tank for the compressed propellant gas. The maximum range is listed as 80 meters, with an effective range between 50 and 70 meters. Also under development is a 75-mm mortar round for use in disseminating riot control agents.

CW defensive research and development efforts are directed primarily toward improving detection and protective equipment and therapeutic agents; a considerable amount of work is undertaken to improve protective clothing items by use of either impregnated or disposable-type clothing for general issue. The Italians are attempting to obtain French and U.S. material samples to enable them to develop a local source for the fabrication of butyl-coated materials.

3. Nuclear energy (S)

For several years, the Italian nuclear research program has been devoted primarily to the investigation of basic concepts with only a minimum effort toward practical applications. These priorities probably will be reversed as a consequence of a law which restructured CNEN in late 1971. Under this law, the agency remains under the operational control of the Ministry of Industry but now is headed by a president with an executive board and a council of administration, all appointed by the Council of Ministers. All major political parties are represented in the CNEN and, as a consequence, the Italian nuclear program is expected to receive increased attention and support from the national government. This new law has been implemented and Ezio Clementi, formerly the director of CNEN's Computing Center in Bologna, has been named President of the CNEN.

Primary effect of this reorganization upon the Italian nuclear research program will be the redirection of the major effort. While basic research will continue, the chief effort now will be toward practical applications, especially in the realm of reactors and reactor fuels. A major research effort will also be expended in controlled thermonuclear reactions research. Also of interest is the investigation of uranium enrichment.

Nuclear electric power is competitive in Italy at a higher cost than in many European countries because of the high cost of conventional fuels and near total exploitation of hydroelectric resources. Large sums of money have been spent for the development of nuclear power by both the government and private industry.

Italy has three power reactors in operation, a fourth one under construction, and others planned. SIMEA, a 210-megawatt electrical (MWe) gas-cooled reactor some 40 miles south of Rome, near Latina, is based on British technology and uses natural uranium fuel. SENN, a 160-MWe boiling water reactor (BWR) on the Garigliano river is based on General Electric technology and uses 2.1% and 2.6% enriched uranium fuel. SELNI, a 257 MWe pressurized water reactor (PWR) near Torino on the Po river is based on Westinghouse technology and uses 2.7% to 3.9% enriched uranium fuel. The fourth plant, a 750 MWe BWR, similar to the SENN reactor, is being built near Cremona and is expected to be operating in 1975. Others, both BWR's and PWR's, are being planned for various locations.

With its expanding nuclear power program, Italy has shown considerable interest in establishing an independent nuclear fuel capability, including uranium enrichment, fuel fabrication, and fuel reprocessing. The Italians have two small fuel processing plants, one in southern Italy about 30 miles from Taranto, and one at Saluggia. The one near Taranto is specifically designed for processing thorium-containing fuels, while the one at Saluggia is for processing enriched uranium fuel elements. Their natural uranium fuel elements from the British-provided reactor are returned to the United Kingdom for reprocessing.

Laboratory research into both gaseous diffusion and gas centrifugation for uranium enrichment is conducted within government facilities with industrial participation. Research efforts are at very low levels and probably are intended only to foster scientific interest in order to provide CNEN with assistance during any consideration of joining in multinational group studies or group sponsorship of production facilities. Italian industry should be able to build and operate fuel fabrication facilities adequate for their program, but Italy will remain dependent upon imports for fuel supplies, since their proven uranium reserves are insufficient to support their nuclear power program.

For several years the Italian Navy has been involved in a program for the development and construction of an 18,000-ton nuclear powered naval support ship to be called the *Enrico Fermi*. It is proposed that this ship be equipped with an 80-megawatt pressurized water reactor using 3% enriched uranium fuel. France provided the fuel for the land-based prototype for this reactor. Italian naval officials have insisted that the ship will be operational in the 1972-73 period. However, it now appears that construction has not even started. Because of the naval association of the vessel, Italy has been unable to get assurances of fuel supplies for an operational reactor. This could change if Italy does become part of any program whereby they would have access to enriched uranium.

Italy has adequate research facilities, including subcritical and critical assemblies and research reactors, to support a nuclear research program and to provide training for the associated personnel. Fundamental and applied nuclear research is being carried out in three types of facilities: 1) three national institutes—Casaccia Center for Nuclear Studies, Frascati National Laboratories, and the National Institute for Nuclear Physics (INFN), all in or near Rome; 2) University facilities that are not associated directly with the national institutes; and 3) nuclear-associated centers such as the Center of Information, Study, and Experimentation in Milan and the Saluggia Nuclear Research Center near Torino. Most of the financial support for INFN is provided by the CNEN. INFN actually is an independent organization of nuclear research laboratories located at 17 Italian universities, at the Frascati National Laboratories, and at the Higher Institute of Health.

The Italian-controlled thermonuclear reactions research is centered at Frascati and is partially supported by Euratom. Although most of the experimental work has been concerned with multimegagauss magnetic fields produced by implosion techniques, this work has now been cut back and a much larger effort has been put into laser-induced fusion research. In addition, research scientists at Frascati are investigating plasma focus phenomena and conducting experiments associated with toroidal geometry devices.

Italy is a participant in several international nuclear energy programs. Euratom provides some funding for the controlled thermonuclear reactions research at Frascati, participates to a small extent in the Italian nuclear power program, and fully operates the Center for Nuclear Research at Ispra. The results from Ispra research projects are shared by all of Euratom, but Italy naturally will be the prime beneficiary. Italy also is a member of the International Atomic Energy Agency (IAEA) and the European Organization for Nuclear Research (CERN).

4. Electronics [5]

Italian electronics research and development efforts lag behind those of the other advanced countries of Western Europe. Basic electric research has been limited primarily by a chronic shortage of funds rather than by any specific technological shortcomings. Nevertheless, impressive results have been obtained through production of systems and components using, where necessary, foreign-designed equipment. This has been possible through a complex system of mergers and/or licensing agreements with companies in the United States, France, the United Kingdom, and West Germany. Such arrangements have lowered the total cost of electronics research and development and have enabled Italy to use its production expertise to greater advantage. Some excellent research is performed by industry and universities, however, and the country's needs are being met by an adequate supply of capable scientists.

The Selenia Associated Electronic Industries, Inc. (*Selenia Industrie Elettroniche Associate* S.P.A.), Rome, is one of Italy's largest electronics research, development, and production organizations and has spearheaded the industry in many NATO projects essential to the defense of Western Europe. The areas of applied research include space and military communications systems, radar, and computers. High-quality work has been done in telecommunications, including development of all-solid-state tactical radio-relay equipment, carrier telephone and telegraph systems, pulse code modulation systems, parametric amplifiers, and communications satellite antennas. Especially noteworthy is their research in microwave propagation and components.

The Italians are doing basic and applied research related to radar and have produced families of tracking and fire-control radars, as well as 3-D search and a 2-D random frequency agile radar. Military radars incorporate a full complement of electronic counter-countermeasures features, such as instantaneous automatic gain control fast time constant, sensitivity time control, staggered pulse repetition frequency and side lobe blanking. Doppler continuous wave radars have been developed for missile guidance applications.

The Italians are making rapid progress in the design and production of equipment for electronic warfare; they currently have significant capabilities both in electronic countermeasures equipment, especially that

for electronic reconnaissance, and in electronic counter-countermeasures techniques. Intercept equipment has been developed for use against ground-mobile communications systems. Shipborne and airborne electronic intelligence and direction-finding systems include some of the latest features in automation and design sophistication. The Italians have experimented with data link systems between direction-finding stations, and integral intercept/jamming systems have been developed for rapid jamming response, as well as look-through capability. The EL70 jammer, a joint German-Italian project, was produced by *Electronicen* of Italy as a deception-repeater jammer able to recognize and counter specific aircraft and missile threats. Other interesting electronic warfare developments are a brute-force jammer to render fire-control radar ineffective beyond a very limited range and a communication link which allows a control station to set frequencies automatically (and other operating conditions) of other stations within the net when a special signal appears.

Infrared activities have included work on communications and detection techniques and in 1970 included infrared signature studies of ships and disposable decoys. The Galileo Works, Florence, has developed an infrared beam-rider missile guidance system and a passive tracker. The shipboard electronics system for the Israeli Gabriel missile system is of Italian design. Other efforts in the military electro-optical field are a combined low-level-level TV radar tracker and later rangefinder systems for fire control.

In the late 1950's and early 1960's, the major Italian electronics company, Olivetti, developed and produced several of its own models of general purpose digital computers. Prior to the sale of its computer interest to a U.S. company, Olivetti also produced other models using licensed U.S. designs. Since the mid-1960's, the only domestically developed Italian computer model has been the Laben-70, made by the *Laboratori Elettronici e Nucleari* in Milan. Special purpose digital and analog computers also have been developed indigenously. An analog-type computer, the model OC14, was built in 1960 and was intended to be part of the fire control system installed in West German army tanks. Selenia has developed the CDD-3032, a third-generation computer incorporating medium scale integration, for military and air traffic control applications. Production of this system is expected to be underway in the near future. Selenia reportedly is also constructing a general purpose digital computer for the next series ESRO satellites.

5. Medical sciences (S)

Lack of funds and equipment has limited advances in biomedical research in Italy, although individual scientists are exceedingly capable. Training for research is good and noteworthy work is being done, particularly in biophysics, genetics, and pharmacology. Research is promoted primarily by the CNR, which has a National Consultative Committee for Biology and Medicine, the Ministries of Health and Agriculture, the universities, and the private sector. Italy relies in part on support from international sources, especially the U.S. National Institutes of Health and the World Health Organization. Major research centers include the Higher Institute of Health of the Ministry of Health, the Mario Negri Pharmacological Research Institute, the National Institute of Nutrition of the Ministry of Agriculture, and the Farmitalia unit of the Montecatini industrial complex.

The level of pharmacological research is high. Fine work is being done on the interaction of drugs, the mechanism associated with the development of arteriosclerosis, the pharmacodynamic action of barbiturates, the synthesis and transport of lipids, species differences in toxicology, and the pharmacogenetic aspects of learning and memory. An interdisciplinary, molecular-biological approach is being made in clinical pharmacology.

In the development of pharmaceuticals, good work is underway on cardiovascular agents, the mechanics of antitumor action, screening of new cancer chemotherapeutic agents, the mechanism of action of psychotropic drugs, and the modification of synthesis of ergot alkaloids. Interesting studies are being contributed to steroid biosynthesis and to the chemistry of antitumor and antiviral antibiotics. The Mario Negri Institute is carrying on research in cancer chemotherapy, neuropsychopharmacology, the pharmacology of lipid metabolism, and the toxicology of industrially important chemicals.

Research in biochemistry is especially active and production reflects investigative areas of worldwide interest. Italian biochemists have exploited a wide range of sophisticated instrumentation, including the electron microscope and gas chromatograph. Current studies have included work on the mechanism of hormone release, the role of prostaglandins and the interaction of neural and hormonal control, functional differentiation of tissue peptides, the action of immunoglobulins, and the diagnosis of brain tumors. The Ministry of Health is supporting the study of clinical laboratory automation. Although Italy has a

limited number of researchers working in biophysics and genetics, they are quite capable. Qualitatively good reports have been made on the effects of chemicals and ultraviolet radiation on cell mutation, the physical chemistry of bone marrow cells, radiobiological methods of study of cell populations, and the effect of radiation on cellular constituents. The CNR is supporting fundamental research on the structure and function of biological macromolecules, the extraction and analysis of ribosome precursors, the study of protein fractions of grain, and the cytotoxic effects of selected drug agents.

Physiologists are doing fundamental research on the physiology of diving; the Italians are interested in aspects of research related to underwater physiology. Areas of production include cardiovascular physiology, neurophysiology, endocrine activity, cellular physiology, and the physiology of respiration. The Higher Institute of Health and the CNR are cooperating in a study of health-related aspects of the Italian environment. Routine studies of the environment and atmosphere pollution are underway at a Euratom facility for nuclear research at Ispra.

Careful research in nutrition is devoted to study of food additives and the microbiology and chemical compositon of food, water and air, the nutritive value of foodstuffs, and biological research on the nutritional process. Italy participates in research work promoted by the Food and Agriculture Organization (FAO) and by the World Health Organization.

Italy has developed modern facilities for research on vaccines. The Higher Institute of Health is developing its competence in pollution research, microbiological synthesis, parasitology, and food microbiology. Italian research is being strengthened in epidemiology, especially of arbovirruses. A fundamental campaign is underway to eliminate intestinal parasites in school children.

The military medical services of Italy conduct active medical research programs in well-staffed research institutes with modern equipment. Subgravity research conducted at the Air Force Center of Study and Research on Aviation and Space Medicine, Rome, has drawn international attention. The Center for Military Applications of Nuclear Energy, a triservice organization, is playing an ever-increasing role in radiation pathology and biology. The financing and coordination of medical research of interest to national defense is carried out by the Defense Scientific-Technical Council, subordinate to the Ministry of Defense. On problems of mutual interest, military medical research institutes coordinate with the National Research Council, the National Committee for Nuclear Energy, the Ministry of Health, other government ministries and agencies, universities, and private industry. Military medical research personnel participate in international scientific and medical meetings and, in some instances, share their findings with participating countries.

6. Other sciences (5)

a. *Chemistry and metallurgy*

Chemistry occupies a strong position in the Italian universities and in industry. Most of the basic research is carried out at the university institutes. Chemical research is stronger in industrial laboratories than in government institutes. The total chemical research effort is only slightly less than that in France but substantially less than that in West Germany or the United Kingdom.

There is considerable strength in several aspects of organic chemistry in Italy, including synthesis, organic reactions, and proof of structure. The University of Milan is strong in the organic chemistry of terpenes, alkaloids, animal and plant pigments, and other naturally occurring products. The University of Genoa also works on terpenes, and the University of Naples does research on pigments of marine organisms. The University of Pisa is involved in studies on organometallic compounds and optically active compounds. Many other universities are active in synthetic organic chemistry. Italian research on high polymers, including both their preparation and the study of their physical properties, is recognized internationally. The outstanding figure is Dr. Giulio Natta, who was awarded the Nobel Prize in Chemistry in 1963 for his significant work on stereospecific polymerization, which led to the development of commercial polypropylene. Dr. Natta has been responsible, as head of the Institute of Industrial Chemistry at the Polytechnic Institute of Milan, for directing a large amount of important research on polymerization catalysts, stereospecific polymerization, isotactic polymers, structure of polymers, and kinetics of polymerization. His institute has been well supported by Montecatini-Edison S.p.A., Milan. Polymer research is concentrated also at the CNR Institute for Macromolecular Chemistry, Milan, which does work on stereospecific polymerizations, behavior of fused polymers as related to synthetic fiber production, and the structure of complex polymers by means of X-ray diffraction, electron diffraction, nuclear magnetic resonance, and infrared techniques.

Industrial organic and inorganic chemistry is strong in Italy. Montecatini-Edison is the largest employer of chemists in the country. In 1966 this company had about 5,100 chemists doing research on polymers, plastics, synthetic fibers, petrochemicals, dyes, agricultural chemicals, organic intermediates, and other industrial chemicals, involving an expenditure of about $32 million. The pharmaceutical industry and several universities synthesize drugs. The Italian chemical industry has been deteriorating rapidly in recent years and suffered a loss of nearly $400 million in 1971 and probably nearly as much in 1972. As a result, it has been difficult for the industry to carry out a development plan.

Much of the research in physical chemistry is directed toward physical organic research. Francesco Minisci at the Milan Polytechnic Institute is known for his research on reactions of free radicals and on syntheses involving free radical reactions. Physical organic research at the University of Milan involves reaction kinetics, catalysis, and stereochemistry. There is research on reactions of aryl radicals and on conformational analysis at the University of Bologna and on reaction kinetics and mechanisms at the University of Padova. Several institutions are involved in electrochemical research. The work of Roberto Piontelli on electrode behavior, overvoltage effects, and metallic dispersions in molten salts at the Milan Polytechnic Institute is noteworthy. The University of Rome does research on electrochemical reductions of organic compounds and on anodizing of aluminum. There is general physical chemistry research at many of the universities.

Research in inorganic chemistry is widespread. Professor Luigi Sacconi of the University of Florence is noted for his research in coordination chemistry, particularly on nickel, cobalt, copper, and other metal complexes. Important work on metal carbonyl complexes involving nickel, cobalt, rhodium, and rhenium is done at the University of Milan.

Several of the Italian universities are strong in biochemistry. Particularly significant is the extensive work by Alfessandro Rossi-Fanelli and Eraldo Antonini of the University of Rome on hemoglobin and myoglobin chemistry. This university also does research on proteins and deoxyribonucleic acid (DNA). Also strong in biochemistry is the University of Padova, which does research on hemocyanin (a respiratory pigment of arthropods and mollusks), proteins, DNA, and various enzymatic reactions, such as mitochondrial oxidations and phosphorylations. The University of Milan does research on protein synthesis and on development of methods for analysis of plasma and urine for hormones and other constituents.

Although Italy has a large metals production industry that is of considerable economic importance, it has not developed a strong capability in metallurgical research and development. The research efforts have been directed principally toward improved methods in extractive metallurgy and in solving steel production problems. The research program lacks the depth and scope of that in most industrial European countries. The program is weak in the areas of fundamental physical metallurgy and metal physics, basic ferrous physical metallurgy, fatigue, creep and rupture, and damage criteria. In overall metallurgical research and development capabilities, Italy is considerably behind West Germany, France, and Czechoslovakia, is about on a par with Switzerland, and is well ahead of Spain and Greece.

The most significant metallurgical research carried out in Italy is that done in the laboratories of Fiat, the industrial giant involved in automotive, aircraft, marine, diesel engine, and power plant construction. Significant research on ferrous metallurgy is also carried out in the laboratories of Italsider, the government-controlled steel company, and in the Cogne Steel Company in Aosta. Noteworthy work is done at the Institute of Light Metals and Alloys in Novara on nonferrous metallurgy and at CNR's Center for the Studies of the Preparation of Minerals in Rome on extractive metallurgy.

Fundamental studies of physical metallurgy and metal physics, which are normally undertaken at universities, are notably lacking. Most efforts along these lines in Italy are directed toward the study of defect structures in ionic compounds (metal halides) and semiconductors. Some excellent research on the electrochemical aspects of stress corrosion cracking of austenitic stainless steels has emanated from the University of Milan.

In the government-supported, nonacademic laboratories, fundamental research is conducted at the Center for Information, Studies, and Experimentation in Milan on point defects, diffusion, and radiation damage in metals and particularly in dilute copper, silver, and gold alloys. Euratom in Ispra has studied radiation-produced point defects in metals, internal friction phenomena in hydrogen-contaminated body-centered-cubic metals, and the potential of improving the ductility of aluminum-aluminum oxide sintered products, called SAP, for potential use as nuclear cladding material. In the field of extractive metallurgy, the CNR Center for Studies of the

Preparation of Minerals in Rome has studied the roasting of nonferrous ores, the flotation of zinc ores, electrochemical refining, and similar subjects.

Steel refining and production problems have been researched at the plant laboratories of Italsider. Work has included iron ore concentration, blast furnace studies, oxygen refining, continuous casting, and steel fabrication. These studies have all been directed toward improvements in steel production. However, little effort on ferrous physical metallurgy has been observed in publications emanating from Italsider facilities. In contrast, the laboratories of the Cogne Steel Company have concentrated their efforts on ferrous physical metallurgy and the development of improved steels and improved heat treatment procedures.

b. *Physics and mathematics*

Italian physics research is concentrated in a few fields, with most of the effort being devoted to the nuclear sciences and technologies (33%) and the physics of solid states (30%). The remaining physics effort is nearly equally divided among the areas of relativity and gravitation, molecular and atomic physics, acoustics, fluid mechanics, magnetohydrodynamics, plasma, quantum electronics, and optics. A major portion of the fundamental research is conducted at the university institutes and laboratories, whereas research of an applied nature is being fostered at the government-supported agencies and in the laboratories of industry.

High-energy research into the physics of elementary particles appears to hold the major interest in the nuclear sciences. The largest portion of such research occurs at the Universities of Rome and Trieste. At the University of Rome, research in elementary particles is fairly up-to-date and comparable with that being done in other advanced countries. Because they have access to the Adone storage ring, the Italians can examine the gamma-gamma interaction processes needed to observe charged pion collision production peaks. Others at the university are investigating multihadronic cross sections based on electron annihilation. They are making theoretical evaluations of results obtained in experimental research in the United States on proton-antiproton annihilation cross sections. Coupled with their advanced theoretical research, Italian physicists at the University of Rome engage in well balanced programs of experimental research. This is possible because they have access to the high-energy electron-synchrotron at Frascati where research dealing with neutral-pion photoproduction on protons from deuterium is being done. High-energy research at the University of Trieste is advanced and of high quality in both theory and experimental work, and studies in photo- and electroproduction, pion distributions in high-multiplicity interactions and resonances, and the photo-production of positive pions are underway. Most of the high energy research done at the other universities is theoretical, excepting that being done at the University of Bari where resonance productions in pion interactions are being conducted in the laboratory.

Basic research in low-energy physics is limited to theoretical studies dealing with the structure of nuclei and elastic scattering cross-sections. Approaches are also being studied which the investigators hope will evolve into new theories concerning unstable states. In experimental research at the University of Bari, measurements of forward scattering angles related to carbon isotopes are underway for the purpose of gaining information concerning angular correlation. Efforts are being directed by physicists at the University of Pisa toward studying forward neutrino-induced reactions on the double-shell nuclei. The low-energy nuclear researchers at the CNEN laboratory in Rome are studying reactions and level structures and decay schemes through the use of an isotope of lutetium. During the past 3 years, CNEN has expanded its own research centers in nuclear physics and engineering, radiation biology, and atomic fuel treatment, and has the responsibility of establishing atomic powerplants in Italy. These involve the 200-megawatt Simea plant with its gas cooled reactor of British design at Latina, the 160-megawatt Senn plant with a General Electric boiling water reactor on the Garigliano river, and the 235-megawatt Selni plant with a Westinghouse pressurized water reactor at Vercelli. CIRENE, the first Italian power reactor (35 megawatts) was developed by the CISE in Milan and is one of the earliest series of experimental power reactors of advanced design financed by CNEN.

Solid state physics research, which lags such research in other advanced countries by 3 years, is concentrated in the various large universities, CNEN laboratories, and industry-supported research institutes. Industrial concerns are interested primarily in solid-state research from the standpoint of semiconductor device development, metallurgy, magnetic materials and, in some cases, the photographic properties of various silver halides. Research also includes studies of local antiferromagnetic ordering commonly observed in ferromagnetic alloys. At the University of Genoa, research deals with magnetic moments of samarium in the various metals

being investigated. Also, some good research is underway in connection with superconductivity characteristics of "Kondo" metals regarding critical fields and temperatures. Such work has objectives related to antiferromagnetic interactions and localized spin fluctuations.

Physicists at the University of Palermo concentrate heavily in semiconductor material and device development and property studies. Their activities include the prototype development of bipolar transistors and diodes, impurity property in silicon crystals, doping of semiconductor layers, tunneling studies, and transmission energy loss of light being channeled through silicon. The research is aimed primarily at improving Italian electronics, which is needed to promote expansions in their computer and communications industries. Some of the most advanced solid-state research is being done at the University of Modena where properties of cadmium tellurides are being investigated in connection with drift mobility of holes.

Fairly advanced but limited research is being done in optics, interferometry, spectroscopy, holography, and quantum electronics. At CNEN, optics specialists are investigating optical signal processing using acoustic light modulators for treating images. Performance characteristics are being studied for optical systems illuminated by coherent light in a linear motion pattern to analyze the far-field diffraction. At the CNR-supported Optics Institute in Naples, research is being conducted on microholographic interferometry. Diffused laser light is being employed to obtain bright field interferograms. Optical spectroscopy research is being conducted at the University of Rome where approaches being used employ grating synthesis. A new technique, which appears to hold promise for producing high-resolution spectroscopy, is being emphasized; it is based on the antistokes intensity caused by photon interactions. The Italians are devoting efforts to classic interferometry experiments dealing with light beams in orthogonal states of elliptical polarization. The CNR laboratories have been following some programs to produce low-noise and high-efficiency production of holograms by developing a process for treating photographic plates to obtain an optimum ratio between noise and efficiency.

There is a strong trend toward increased research in magnetohydrodynamics and plasma physics involving studies on classic plane magnetohydrodynamic and laminar motions and plasma stabilities in specific media. Fluid mechanics research related to hydrodynamics and reactor engineering is concerned with the general theorem for nonlinear problems and boundary conditions corresponding to the motion of viscous fluids in tubes with a permeable wall.

Italy has a few scientists who pursue research into gravitation and relativity. Physicists well known throughout the world in this area are P. D. Vincensini and M. Mignani. A limited amount of research in atomic and molecular physics is carried out at the Universities of Bologna and Naples. Studies deal with the specific compounds of monochloramine and dideuteroacetylene and involve analyses of fundamental and "hot bands" that are useful in interpretation of their near infrared spectrum through use of microwave spectroscopy. Studies related to inorganic molecules comprise investigations of the vibration spectra of cobalt and rhodium carbonyls. Much of the research in acoustics and ultrasonics is related to oceanography and the propagation of sound in water. Notable work is done in ultrasonic cavitation and the utilization of shockwaves for studying the structure of solid materials and for nondestructive testing.

Mathematics has a highly respected place in the scientific community, and Italian mathematics have long been capable and productive. For example, mention should be made of the work of mathematician Ricci (19th century) for his work on tensor calculus, which underlies much differential geometry and relativity theory. Also, during the present century, mathematician physicist Enrico Fermi contributed greatly to the development of atomic energy.

Strong research areas for Italian mathematicians now include analysis, especially ordinary and partial differential equations and operator theory; geometry, both differential and algebraic; mathematical physics, especially quantum mechanics; and numerical analysis. The country's total research output is among the best in Western Europe, and the work is typically of good quality. An indication of wide acceptance of the work is that much is published abroad, largely in the United States but also in many other countries. The Italians also publish several good mathematical journals; *Nuovo Cimento* is a much used international vehicle for mathematical physics. The reputation of Italian mathematicians may be less than it was two or three generations ago, but it is still quite good.

In the *World Directory of Mathematicians*, there are 868 Italians listed; their numbers follow those of the United States and the U.S.S.R. While the Italians do produce many research papers (about 2% of the world output reviewed in the most comprehensive abstract journal), their output seems a little low for their long list of prominent mathematicians. This may be related to a criticism that has been stated regarding

the Italian academic system, namely, that professors are "kings," and, although a man must work diligently to become a professor, he has little requirement to do much research after he attains the rank. There are, of course, some professors who are doing research, but the overall research productivity per man appears low.

At the lower levels of Italian university education, mathematics is apparently emphasized, laying the foundation for broad use of mathematics in many fields. However, advanced education in mathematics seems less organized. Thus, for example, in 1971 only three Italian universities (Bari, Pisa, and Torino) had established work in computer science. Several research institutes have since been established to help bridge the gap. One of these is the Institute for Information Processing, formerly the Center of Studies of Electronic Computers in Pisa. This institute collaborated with the Olivetti Corporation in developing early Italian computers; it now does research in numerical analysis and various branches of applied mathematics, and it collaborates in instruction with the University of Pisa. Other research institutes include the Institute of Applied Mechanics for Aerial Dynamic and Gas Dynamic Engines, connected with the Torino Polytechnic Institute, and the Numerical Analysis Institute, connected with a university in Rome. The institutes contain or have access to substantial computing facilities, including in Pisa an IBM 7090 plus other machines, in Torino an IBM 360/44, and in Rome a UNIVAC 1108. Substantial computing facilities appear to be widely available.

Italian industry was slow to use mathematicians, although several leading mathematicians have concentrated their efforts on fields such as shell theory, numerical analysis, and recognition of characters. The use of computers was stimulated in late 1968 with inauguration of the UNIVAC Advanced Systems Computer Center in Rome.

There has been substantial cooperation in mathematics between Italy and the U.S.S.R. Collaboration in use of methods of calculation has been conducted under the Mixed Commission for Soviet-Italian Scientific-Technical Cooperation. In 1970 the General Electric Information Systems Italia contracted to supply two large electronic computers, type GE-425, to a motor vehicle plant in Moscow. By 1971 the Olivetti Corporation appeared to be a world leader in use of computers for machine design. In doing this they seemed to have made clever use of U.S. scientific findings. In June 1972 it was reported that the Olivetti Corporation had, since mid-1970, sold large quantities of automatic machine tooling to the U.S.S.R., including computer programming and electronic numerical control equipment known as "Inductosyns," a kind manufactured in the United States. The U.S.S.R. was also reported attempting to acquire the technology for its own production of the Olivetti machine tool systems. In 1970 the CGE FIAR Defense and Commercial Electronics Department at Milan had licensing agreements with the General Electric Company and AEG Telefunken and specific agreements with several U.S. companies in the computer field. The FIAR was pursuing projects in several military applications. The Italian mathematical effort is fairly strong and quite competent. It includes a substantial trend toward applications, which is particularly noteworthy now in work on numerical analysis and computing, but which Italian industry seems to have been somewhat slow to utilize.

c. *Astrogeophysical sciences*

In general, Italy is not outstanding in astronomy. However, better-than-average work is done in solar astronomy, which is emphasized. While there are more than 15 astronomical observatories in Italy, including small private installations, most equipment is mediocre. For stellar work, however, Italy has two of the largest telescopes in Western Europe. One is a 50-inch reflector at Merate, an observing station of the Brera Astronomical Observatory, Milan; the other is a 48-inch reflector at the Astrophysical Observatory, Asiago, of the University of Padova. At the Astrophysical Observatory of Catania, Sicily, stellar research emphasizes the study of stars that exhibit activity believed to be similar to that of the sun, such as flare, spotted, and magnetic stars. The Catania observatory is also a solar patrol station. Other optical or radio solar research facilities are located at Bologna, Florence, Rome, and Trieste. All of these observatories participated actively in the International Active Sun Years (IASY) programs (1960-71). An International Astronomical Latitude Station at Carloforte has participated in studies of variations in the position of the pole, while the Astronomical Observatory of Torino has been the site of the Central Bureau of the Latitude Service and is supported by the International Astronomical Union and the IUGG. The Vatican has an observatory which specializes in studying the structure of the Milky Way galaxy at Castelgondolfo. Italy has a relatively modest but on-going space research program. The Italian aerospace industry was responsible for the design, development, and construction of all the test satellites and some electronic space-borne and ground equipment for the

ELDO Europa-I launch vehicle program, which concluded in June 1970. It continues to be involved to a lesser degree in some aspects of the Europa-2 program. The industry has contributed to the design and development of electronic and other components for the major satellite projects of ESRO; Italy has also cooperated in ESRO programs by designing satellite and sounding rockets onboard scientific experiments and has also made available to ESRO its Salto di Quirra rocket launching range on the southeast coast of Sardinia.

The country has cooperated extensively with the U.S. NASA since 1960. Initially, rocket-launched sodium vapor high-altitude wind studies were made from the Salto di Quirra range. The San Marco project was cooperatively begun in 1962, under which Italy established the San Marco launch range near the equator off the Kenya coast of Africa. The range consists of two platforms a few miles out in Formosa Bay. One, the San Marco, is the launch platform; the other, the Santa Rita, is the base for launch control and tracking facilities. Italy has designed, built, and launched three scientific satellites under the San Marco program: the San Marco 1, launched in 1964 from Wallops Island, Virginia; the San Marco 2, launched from the San Marco range in 1967 (the first scientific satellite to be placed by any nation into an equatorial orbit); and in April 1971, the San Marco 3, the last of the series, was also launched from the San Marco range into an equatorial orbit. In March 1970, the CNR and NASA established an agreement by which the latter will provide reimbursable launchings for Italian scientific spacecraft. The first expected to be launched under this agreement is the Italian SIRIO satellite. This is a communications and scientific satellite to be placed into earth synchronous orbit from Cape Kennedy.

In March 1972 a new series of sodium vapor high altitude wind studies was begun with the launching of a Nike-Apache rocket from the San Marco range. The Italians have also developed and utilized meteorological rockets for sounding the atmosphere at somewhat lower levels. In 1970 an inexpensive two-stage rocket was under development, the first stage of which is recoverable and is propelled by chemically generated steam. The U.S. Air Force was partially supporting the development of the second stage, which is propelled by the combustion of metals in water.

Italy is a member of the International Telecommunications Satellite Consortium (INTELSAT). Its major ground terminal is located at Conco del Fucino, about 60 miles east of Rome. A second terminal at a new site about 90 miles from Rome is planned. This will supplement that at Fucino and will work with the SIRIO satellite.

Italian meteorological research is limited and not particularly significant. The country has several government agencies concerned with the area, but the Air Force Meteorological Service, which is attached to the Inspectorate for Telecommunications and Flight Assistance of the Ministry of Defense, is responsible for serving both civil and military interests by operating the country's major synoptic observing and forecasting stations. The director, Maj. Gen. Prof. Dr. Giorgio Fea, represents Italy in the World Meteorological Organization (WMO) as a member of that organization's Executive Committee. Besides its six administrative divisions, the service headquarters supervises three main meteorological offices through the Analysis, Forecast, and Meteorological Information Center and supports four semiautonomous research institutes, the most important being the Institute of Atmospheric Physics in Rome.

The Institute of Atmospheric Physics is one of the main research bodies of the CNR and was founded to promote, intensify, and coordinate the research activity in meteorology and atmospheric physics in Italy. The activities of the Institute of Atmospheric Physics range from theoretical studies and experiments to specialized education and training. These multifold activities, developed in close collaboration with the Italian Meteorological Service for Aviation, are carried out through the use of scientific and technical services, workshops, a vast library, and close relationship with relevant national and international bodies. The Institute of Atmospheric Physics has been directed by the CNR to develop two distinct programs. The first has the double purpose to up-date the National Meteorological Organization and its equipment and to realize a more efficient weather forecasting system able to provide realtime warnings of hazardous weather for the protection of life and property. This program will span 5 years and cost about $25 million, approximately half of which will be spent by the Air Force Meteorological Service to establish a radar warning net of at least 10 weather radar stations to augment the present network of six stations. Equipment utilized by this project will be provided by the Industrial Society of Automatic Electronic Products (SIAPE) of Bologna. This company also develops and produces computer systems and various other electronic equipment for use in meteorological operations. The second project being developed is concerned with the establishment of an International Center for studies and research on meteorology and dynamic climatology of the Mediterranean with

international collaboration at the Institute of Atmospheric Physics and an International School of Mediterranean Meteorology under the sponsorship of WMO.

Italian university level instruction in meteorology is extremely inadequate with only the High Institute of Naples and the Naval Hydrographic Institute supporting Chairs of Meteorology. Satisfactory results, on a limited scale, have been achieved through university and postgraduate level courses at IFA. Despite official recognition of a need for restructuring and expanding technical, scientific, and training programs, it is considered that multiplicity of responsibility and inadequate funding will restrict early realizations of these goals. A number of key Italian scientists in the field are known internationally and have published considerably on meteorology.

The Italian research effort in geodesy and gravimetry compares well with the general average of other European countries, and scientific and technical capabilities are rising slowly and are being used to augment the military and the economic potential. The Military Geographic Institute in Florence, under the Army General Staff, is the official government agency responsible for most Italian geodetic accomplishments. It is one of the best equipped facilities of its kind in Europe for research and experimental studies in geodesy and is staffed by highly competent and qualified personnel.

Horizontal control surveys have resulted in the complete revision of the national first-order triangulation network. Recent activity also has included primary and secondary triangulation work along the Ionian, Calabrian, and North-Sicilian coastal band and measurements across the strait to connect Sicily with the mainland.

Within the framework of the International Gravimetric Commission, the Observatory for Experimental Geophysics in Trieste is collecting and preparing the observational data related to the pendular and gravimetric measures for a new gravimetric standard and for the world gravimetric network. Final adjustment of these programs will be carried out with U.S. and Canadian groups.

Hydrologic and hydraulic research programs compare favorably with those of the more progressive countries in Western Europe. Research is performed at approximately a dozen modern laboratories, the majority of which are in the northern part of the country. Most are connected with universities and are financed by the government and by private contracts; all have computer facilities, and many of the laboratories have such facilities on the site. The research is mostly of an applied nature and is directed toward the production of electric power, the maximum exploitation of water resources, and the improvement of irrigation systems and navigable inland waterways. In hydrologic research, emphasis is on ground water flow, irrigation works, sediment transportation, sea and brackish water desalinization, and water pollution control. Significant hydrologic research is carried out at several laboratories with the principal one at the Institute of Hydraulics and Hydraulic Engineering of the Polytechnic University of Milan. Hydraulic research is performed on a wide variety of subjects, but the work is concerned primarily with density currents, general fluid mechanics, scour, cavitation, dynamic behavior of hydraulic machinery, and the best design and location for surge tanks, stilling basins, locks, weirs, sluice gates, spillways, valves, culverts, and siphons. Italian hydrologists and hydraulic engineers are active in national and international scientific organizations and conferences, particularly the technical committees.

Terrestrial geophysical research in Italy is conducted primarily by the universities. The University of Genoa has a geomagnetic station in northern Italy, at which continuous observations are made of geomagnetic field parameters, micropulsations, and whistlers. These data are utilized to study the characteristics of the magnetosphere. Other magnetic stations are located on the islands of Capri and Ponza and at the Vesuvian Observatory. This observatory also engages in volcano research, as does the Institute of Volcanology of the University of Catania. An Experimental Geophysics Observatory, Trieste, has included a seismological station equipped to conduct marine seismic surveys. The Observatory has engaged also in privately financed geophysical exploration activity.

Oceanography in Italy has for several years suffered from inadequate funding. Although annual appropriations for science have increased significantly each year, such programs as oceanography can only be financed adequately at the expense of basic research, which receives most of the research and development funds. To rectify this situation, the Commission for Oceanography of the CNR has prepared a report on the present status of oceanographic research and on plans and requirements for the period 1972-76. In addition to the list of program goals, the report mentions the scarcity of well trained scientists and technicians and estimates that 300 new people will need to be added to this field during the buildup period. To support the proposed programs adequately, funds must be increased from $4.5 million in 1972 to

nearly $9.0 million in 1976, with an additional $2.0 million for building programs.

The acquisition of the 1,400-ton oceanic research ship *Bannock*, a gift from the United States, and the 830-ton, 180-foot research ship *L. F. Marsili*, equipped with two modern laboratories and purchased by the CNR in 1970, has increased Italian capability for oceanographic data collection and in the training of oceanographers. The 85-ton research ship *U. D'Ancona*, operated by the Marine Biological Institute in Venice, is used for biological research in coastal regions. Italy has purchased a second two-man general purpose research submarine, which is scheduled for delivery in 1972. Italy also has made significant advances in the use of free diving techniques for marine research.

Research conducted at the Antisubmarine Warfare Research Center in La Spezia, established by NATO in 1959, has helped the Italian oceanographic effort. Studies in physical oceanography and other oceanographic aspects of concern to antisubmarine warfare are carried out by the center. The Laboratory for the Study of Radioactive Contamination of the Sea, also at La Spezia, is developing new sampling techniques. An Institute of Marine Biology near Trieste and operated by the University of Trieste has been completed. It will concentrate on the study of marine fauna and flora of the Adriatic Sea. Other Italian facilities conducting marine biological and oceanographic research are the Institute of Experimental Thalassography and the Geophysical Observatory in Trieste, Italian Center for Thalassographic Studies in Venice, the Zoological Station and the Navy Hydrographic Institute in Naples, and the Laboratory for Marine Geology in Bologna.

Italy's interest in international oceanographic activities has increased during the last several years. The country is a member of the more prominent international oceanographic organizations such as the International Commission for the Scientific Exploration of the Mediterranean Sea (ICSEMS), International Council for the Exploration of the Sea (ICES), and the Intergovernmental Oceanographic Commission (IOC). Italy participated in a six-nation survey of the eastern Mediterranean Sea during August-September 1967. During the survey, they collected bathythermograms, marine organisms, bottom samples and cores, as well as data on internal waves, physical properties, and meteorology. Italy is participating in a cooperative oceanographic program in the Icelandic region along with the other NATO countries. The various phases of the program involve sea ice observation, environmental training, ocean thermal structure, geophysical surveys, and hydrographic surveys. Italy hosted a United Nations FAO Conference and Seminar on Marine Pollution that was held in Rome during December 1970.

Coastal research is concerned primarily with sea level changes in the Tyrrhenian, Ligurian, and Adriatic Seas and on methods of arresting beach erosion by artificial accretion. Other research projects are concerned with coastal improvement and protection methods, sea waves, sedimentation, seiches, seismic refractions, and currents. A large part of the research is performed at ELC-electroconsult, a research company in Milan, the Institute of Hydraulics and Hydraulic Engineering, Torino, and the Hydraulic and Hydraulic Structures Institute, Genoa.

Glossary (u/oo)

Abbreviation	Italian	English
CIAS.....	*Comitato Interministeriale per Ricerche Spaziali*	Interministerial Committee for Space Activities
CIPE.....	*Comitato Interministeriale per la Programmazione Economica*	Interministerial Committee for Economic Planning
CISP.....	*Inter-Comitato Commissione per lo Studi Problemi Spaziale*	Inter-Committee Commission for the Study of Space Problems
CNEN.....	*Comitato Nazionale L'Energia Nucleare.*	National Committee for Nuclear Energy
CNR.....	*Consiglio Nazionale delle Ricerche....*	National Research Council
ENEL.....	*Ente Nazionale per L'Energia Elettrica.*	National Electric Power Agency
INFN.....	*Istituto Nazionale di Fisica Nucleare..*	National Institute for Nuclear Physics
SAS.....	*Servizio Attività Spaziale.....*	Space Activity Service
SIAPE.....	*Società Industriale Automatismo Prodotti Elettronici*	Industrial Society of Automatic Electronic Products
...	*Centro de Studi Nucleari della Casaccia.*	Casaccia Center for Nuclear Studies
...	*Centro Informazioni Studi Esperienze.*	Center of Information, Study, and Experimentation
...	*Istituto di Elaborazione della Informazione*	Institute for Information Processing
...	*Istituto di Meccanica Applicata alle Macchine Aerodinamica Gasdinamica*	Institute of Applied Mechanics for Aerial Dynamic and Gas Dynamic Engines
...	*Istituto per le Applicazione del Calcolo..*	Numerical Analysis Institute
...	*Istituto Sieroterapico e. Vaccinogeno...*	Serumtherapy and Vaccinogen Institute
...	*Istituto Superiore di Sanità.....*	Higher Institute of Health
...	*Laboratorio Gas Ionizzati.....*	Frascati National Laboratories

Places and features referred to in this chapter (U/OU)

	COORDINATES			
	°	'N.	°	'E.
Anzio	41	27	12	37
Aosta	45	44	7	20
Asiago	45	52	11	30
Bari	41	08	16	51
Bologna	44	29	11	20
Cagliari	39	13	9	07
Camerino	43	08	13	04
Capri (*isl*)	40	33	14	13
Carloforte	39	08	8	18
Casacria	42	03	12	17
Castelgandolfo	41	45	12	39
Catania	37	30	15	06
Conca del Fucino (*basin*)	42	01	13	31
Cremona	45	07	10	02
Ferrara	44	50	11	35
Florence	43	46	11	15
Frascati	41	48	12	41
Garigliano (*strm*)	41	13	13	45
Genoa	44	25	8	57
Iepra	45	49	8	37
Ivrea	45	28	7	52
L'Aquila	42	22	13	22
La Spezia	44	07	9	50
Latina	41	28	12	52
Merate	45	42	9	25
Messina	38	11	15	34
Milan	45	28	9	12
Modena	44	40	10	55
Naples	40	50	14	15
Novara	45	28	8	38
Padova	45	25	11	53
Palermo	38	07	13	22
Parma	44	48	10	20
Pavia	45	10	9	10
Perugia	43	06	12	22
Pisa	43	43	10	23
Po (*strm*)	44	57	12	04
Ponza (*isl*)	40	54	12	57
Rome	41	54	12	29
Salsuggia	45	14	8	00
Sassari	40	43	8	34
Sardinia (*isl*)	40	00	9	00
Sicily (*isl*)	37	30	14	00
Siena	43	19	11	21
Taranto	40	28	17	14
Trieste	45	40	13	46
Torino	45	03	7	40
Venice	45	27	12	21
Vercelli	45	19	8	25