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NATIONAL INTELLIGENCE SURVEY

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21

Science

NATIONAL INTELLIGENCE SURVEY PUBLICATIONS

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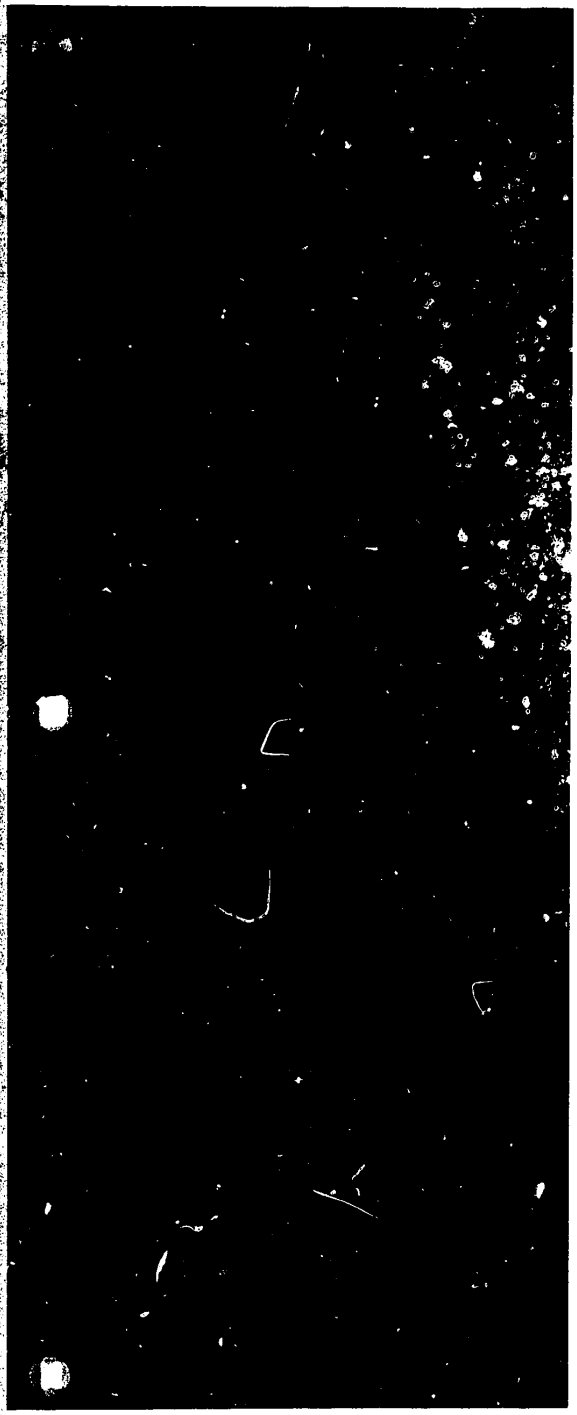

BRAZIL

CONTENTS

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

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FIGURES

Science

A. General (S)

The Brazilian capability for scientific research and development, although one of the foremost in Latin America, is limited. Despite serious difficulties over the past several years, often related to political problems, science in Brazil is improving and the government is increasing substantially its support of research and development. However, many Brazilian and visiting scientists and engineers believe that the rate of development in science and technology is insufficient to meet the needs of the country if it is to escape underdeveloped status within the next 25 years. Much of the scientific effort is concerned with trying to keep abreast of worldwide scientific developments. Biomedicine, chemistry, and physics are reasonably well developed, but the research accomplished is not significant. Research in tropical medicine, antitoxins, and snake venoms has received some international recognition in the past. Generally, scientific projects of significance have been almost entirely dependent on participation by foreigners. Since the early 1950's, Brazil has made rapid progress industrially, but the development of science and technology has not kept pace with this industrial growth, which is based to a considerable extent on the investment of foreign capital. Most of the required technology has been imported from abroad, resulting in little growth of native scientific capabilities. There is practically no communication between practicing engineers and scientists in the academic sector.

The Brazilian Government is aware of the impact of science and technology on economic and social progress and encourages scientific activities, but there are many hindrances to scientific progress. One of the most serious is the inferior system of primary and secondary education which limits the number of secondary school graduates who are satisfactorily prepared for university work. The increased amounts of government funds available for research are still inadequate, and the increases have been partly neutralized by the continuing rapid inflation of the currency. The overall scientific capability is limited by the shortage of trained manpower, and scientific education is hampered by an insufficient supply of qualified teachers, facilities, and funds. The military governments under the late President Costa e Silva and the current administration of President Medici have shown a continued interest in science and technology, but many actions of the government have had an inhibiting effect on scientific and technological progress. The removal of prominent scientists from their positions in universities and research institutes for political reasons has adversely affected morale. Foreign exchange controls have interfered with the

importation of scientific equipment and journals. There have been difficulties in securing government approval for foreign travel by Brazilian scientists and engineers and in obtaining permission for scientific expeditions to Brazil by foreigners. In general, bureaucratic controls and delays have had a stifling effect on Brazilian science and on the inflow of technology from abroad.

Brazil has cooperative agreements in scientific affairs and in atomic energy matters with many countries. In December 1971 a 5-year agreement aimed at intensifying cooperation between U.S. and Brazilian scientists was signed. In recent years, technical and scientific cooperation agreements have been signed with Israel, West Germany, Czechoslovakia, the United Kingdom, France, Japan, several Latin American countries, as well as several other countries. Similar agreements are in effect with the United Nations, which is currently financing about US$5.6 million worth of scientific and technical cooperation projects in Brazil, and with the Organization of American States (OAS). During the last 10 fiscal years an average of about $15 million per year has been allocated to joint technical cooperation programs in Brazil by the U.S. Agency for International Development (AID). In FY72 the allocation through AID had decreased to about $8.9 million. Increasingly, the United States is supporting scientific development in Brazil through such organizations as the U.N. Educational, Scientific and Cultural Organization (UNESCO), the OAS, and other international agencies. Under a basic technical cooperation agreement signed in September 1970, the Japanese Government awards fellowships to Brazilians for technical training in Japan and supplies equipment, machinery, and material, as well as technical support in various ways.

A bilateral agreement for scientific cooperation between Argentina and Brazil, which was signed in 1966, provides for the exchange of information and personnel, communication of research progress, and planning of long-range research for mutual benefit. This agreement was an important step in promoting closer cooperation between the two major scientific communities in Latin America. France and Brazil have rather broad agreements on utilization of atomic energy for peaceful purposes, including provisions for exploration of various regions within Brazil for uranium and thorium. A broad agreement signed by Brazil and West Germany in 1969 gives special emphasis to cooperation in such subjects as nuclear energy, space and aeronautics, oceanography, and data processing. The Brazilian Government has usually pursued a course of foreign policy based on cooperation with the West, and Brazilian scientists generally are Western oriented. Although Brazil maintains diplomatic relations with the U.S.S.R. and other Communist countries, it is believed to have no scientific agreements with these countries.

Brazil is a member of such international scientific organizations as the World Meteorological Organization (WMO), the International Oceanographic Commission (IOC), the International Union of Geodesy and Geophysics (IUGG), the Committee on Space Research (COSPAR), and the International Atomic Energy Agency (IAEA).

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

Research and development activities are not highly organized, and until the early 1950's such activities were left almost entirely to the universities, some of which are federally supported, some under the control of the states, and some privately operated. Most of the research underway is supported by the federal or state governments, or by foreign countries and organizations. Industrial research is weak, and very little financial support for research is provided by industry. Technology is readily available from foreign countries whose industrial organizations participate in Brazilian industry and supply the know-how.

The government controls scientific activities through various ministries and through three major government organizations: the National Research Council (CNPq), its subordinate Institute of Space Research (INPE), and the National Nuclear Energy Commission (CNEN). The Ministry of Planning and General Coordination has become increasingly involved in science and technology and is a major factor in developing science policy and in the funding of scientific research and technological development projects. The federal government organization for scientific and technical activities is shown in Figure 1.

The CNPq, established in 1951, continues to be the single most important government agency responsible for the coordination and stimulation of scientific activities. It provides grants for research, recommends approval of scientific expeditions, provides scholarships for scientific study, and administers bilateral agreements with other countries. The CNPq is comprised of 27 members and includes representatives of all the federal universities, the Academy of Sciences, the armed forces, and the Ministries of Foreign Affairs, Agriculture, Education, and Industry and Commerce. For many years the CNPq was active only in Rio de

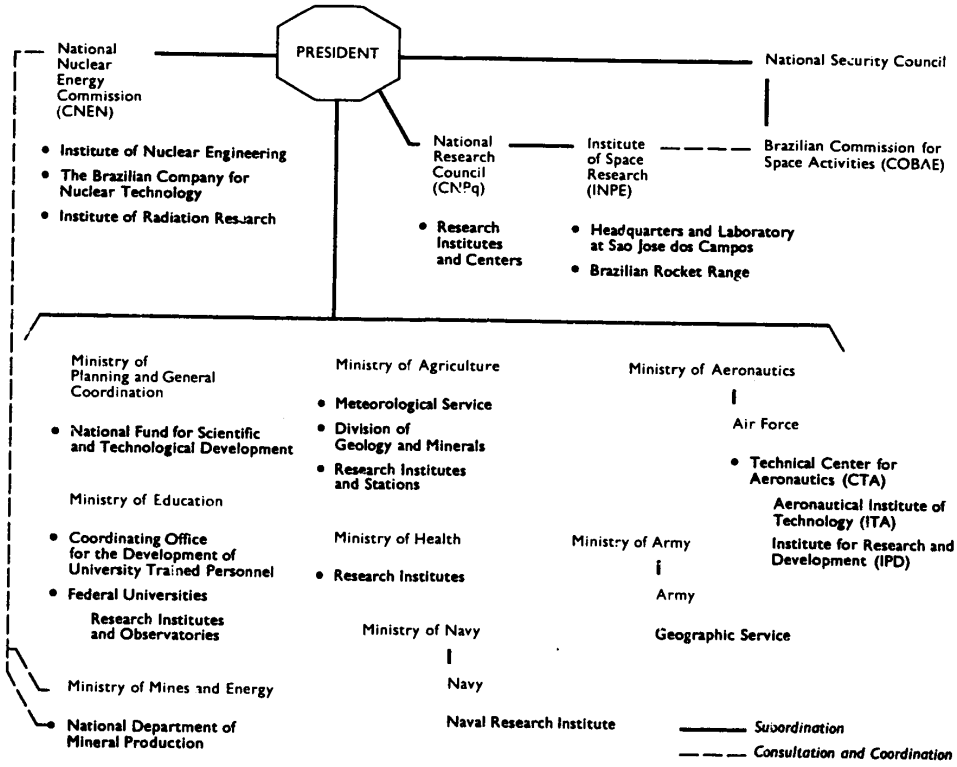

FIGURE 1. Federal government organization for scientific and technical activities, 1972 (U/OU)

Janeiro, but since 1963 its influence has grown because it has been able to provide increasing funds for research projects. The CNPq has the power to establish new research institutes and centers, to maintain direct contact with scientific attaches of foreign countries, and to deal directly with all federal, state, municipal, and private agencies. It also has the authority to create committees and commissions without requiring submission of its recommendations to the President of Brazil. The CNPq plans and oversees the execution of short-term and long-term scientific programs, ensuring that they are constantly revised and kept up-to-date. Another of its functions is to effect liaison between ministries, government agencies and departments, policy planning bodies, and research bodies in order that facilities and resources are effectively utilized. It maintains an objective of stimulating research to secure the best possible use of the natural resources of the country to improve its economy and make contributions to the health and welfare of the population.

Since 1962 the CNPq has operated under 5-year plans, which have reaffirmed the importance of science and technology and set forth priorities for research and development. The CNPq receives its funds chiefly from the federal budget; to date these funds have been insufficient to permit the council to achieve the objectives of its plans. Approximately 50% of its budget is allocated for the support of fundamental sciences, 15% to technological sciences, 25% to medical sciences, and 10% to agricultural sciences. It also has received special grants from the Ford Foundation and some assistance from West Germany and France. In addition to supporting the INPE, the CNPq provides direct financial assistance to the Institute of Pure and Applied Mathematics in Rio

de Janeiro, the National Institute for Research in the Amazon at Manaus, the Institute of Bibliography and Documentation in Rio de Janeiro, the Institute for Highway Research in Rio de Janeiro, and the Emilio Goeldi Museum in Belem.

The CNEN, established in 1956, directs the Brazilian nuclear energy program. Affiliated with the Ministry of Mines and Energy and the National Department of Mineral Production, the CNEN supervises three facilities—the Institute of Nuclear Engineering in Rio de Janeiro, the Institute of Radiation Research in Belo Horizonte, and the new facility, the Brazilian Company for Nuclear Technology (CBTN), Brasilia. Research and training are carried out in the two institutes, which are associated with the federal universities in the cities in which they are located. The CBTN, formed in December 1971, now operates the nuclear research institutes in Rio de Janeiro and Belo Horizonte. The Institute for Atomic Energy (IEA) in Sao Paulo[1] is a separate state facility and is the largest nuclear research institute in Brazil. The CNEN is concerned with the national nuclear policy. It supervises safety regulations and training of nuclear science specialists and reviews proposals for the construction of nuclear energy generating stations. CNEN's scientific and technological research departments provide assistance as well as radioactive isotopes and safety advice to research institutions. The CNEN does not arrange regular scientific meetings but does encourage participation by Brazilian specialists in conferences, colloquia, and symposia. CNEN is financed directly through the government, and some revenue is obtained from its industrial work. During 1971 the CNEN underwent a restructuring in regard to its board of directors. At the present time CNEN is governed by a deliberative commission and by technical and administrative organs deemed necessary to accomplish its objectives.

Brazil is continuing its interest in space activities and in January 1971 the government established a Brazilian Commission for Space Activities (COBAE) under the National Security Council. Headed by the chief of the general staff of the armed forces, the COBAE is concerned mainly with assisting the President in the formulation of a national policy on space research, including the allocation of resources, coordination of civilian and military space programs, and initiation of cooperative programs with other countries. The National Commission for Space Activities (CNAE), organized under the CNPq in 1961 to coordinate, stimulate, and carry out studies related to space activities, was abolished in April 1971 and replaced by the Institute of Space Research (INPE). The INPE absorbed the functions of the CNAE. In addition, it has the authority to formulate plans and programs for space research, as well as negotiate contracts with foreign or international agencies. The head of the CNPq acts as chief of the INPE directorate council, which includes a representative of the general staff of the armed forces. The INPE is the country's representative to COSPAR and participates in international conferences arranged by that organization, the International Council of Scientific Unions, and the Latin American Center for Space Physics. The headquarters and main laboratories of the INPE are located near the Technical Center for Aeronautics (CTA) at Sao Jose dos Campos in Sao Paulo State.

A significant trend is appearing in state government encouragement of research applied to solving problems common to particular areas. Proliferation of official state organizations active in science and technology has resulted from pressures exerted by scientists and technologists who felt that their skills would be better used in an area where they are needed.

There are a few private research organizations, such as societies and associations, that have special interests in various sciences and technologies. Typical are the Association of Research Workers of Rio Grande do Sul and the Brazilian Society for the Progress of Science. Both are concerned with science but do not have laboratories, nor do they employ workers engaged directly in research. The Brazilian Society for Metals, which has been functioning for the past three decades, generally provides a forum for metallurgists, and as such it stimulates research and metallurgical studies of general interest. The Brazilian Petroleum Institute is a private institution but receives support from the state petroleum organization PETROBRAS and all firms connected with the petroleum industry in Brazil. It studies technical problems that are best solved by cooperative work in industry and acts as a consultative forum.

The governmental ministries are concerned with research in various ways. The Ministry of Education is responsible for research in the federal universities; however, neither basic nor applied research is conducted on a broad scale in the universities, and there are few departments or laboratories where research is done systematically or according to normal international standards. Studies generally are done on regional problems, especially in basic medical or

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

geological subjects. The Ministry of Health has many research institutes subordinate to it; among the most notable are the Oswaldo Cruz Institute in Rio de Janeiro and the Evandro Chagas Institute in Belem. The Ministry of Agriculture has regional laboratories and research stations in several places, usually associated with a nearby university. It directs the Meteorological Service and the Division of Geology and Minerals. The Ministry of Mines and Energy operates the National Department of Mineral Production. The ministry is concerned with mining uranium and thorium and with the generation of hydroelectric power; the CNEN coordinates the ministry's involvement in any aspect of nuclear power generation, as well as in the processing of uranium ores. The CNEN does not exercise any special control over geological exploration for basic nuclear ores.

The Ministry of Aeronautics, through the air force, directs research at the CTA. The CTA has two subordinate organizations, the Aeronautical Institute of Technology (ITA) and the Institute for Research and Development (IPD), both at Sao Jose dos Campos. The Ministry of Army is responsible for the activities of the Geographic Service of the Army, while the Ministry of Navy directs the Naval Research Institute on Ilha do Governador. The Ministry of Industry and Commerce administers the Fund for Support of Technology which provides funds for the establishment of new technologically advanced industries. The Ministry of Planning and General Coordination provides financial support for research and development through its National Fund for Scientific and Technological Development, which was created in 1969 by presidential decree.

The Brazilian Academy of Sciences in Rio de Janeiro, established in 1916, functions informally. It holds symposia, publishes scientific literature, provides for the exchange of scientists, and tries to interest students in scientific careers. It is composed of a group of scientists who meet periodically to discuss and study various aspects of accomplishments in scientific fields. It has been assured of government financial support only since 1966. The funds provided, however, are not sufficient to support a scientific research program and are mainly used to cover the cost of the academy's publications.

Although financial support of research and development is extremely inadequate, amounting to only about 0.2%-0.3% of the gross national product, the government recognizes the importance of research and the need for increased funding. Financial support has increased substantially since 1964, but rapid inflations has offset some of the gains. A complete breakdown of funds appropriated or expended for research and development in Brazil is not available. For the second 5-year plan (1968-72) of the CNPq, the Ministry of Planning and General Coordination allocated about $8.8 million for research activities. Of this amount $1.1 million was to be used for 405 postgraduate and doctoral scholarships abroad; $1.4 for CNAE activities; $1.8 for research equipment; $2.2 for research in priority projects; and $2.25 for contract research.

The following tabulation shows a partial breakdown of 1970 research funds (in new cruzeiros; exchange rate of 6.1 = $1) by various government agencies:

CNPq	68,366,110
Ministry of Planning and General Coordination	59,000,000
Brazilian Academy of Sciences	980,000
CNEN	54,000,000
National Bank of Economic Development	91,000,000
National Institutes of Weights and Measures	4,300,000
	277,646,110

The planning ministry's National Fund for Scientific and Technological Development had a budget of $10 million in 1970 and about $25 million in 1971; it provides funds either directly to major research organizations, such as the CNEN or the CNPq, or as a result of requests by individuals for specific research projects. The National Bank for Economic Development, Rio de Janeiro, has two subordinate bodies specifically designed to aid science and technology in Brazil: the Technology Fund and the Productivity Fund. In 1970 the former had 75 million cruzeiros available for fellowships and support of graduate courses and for support of theoretical and applied research without immediate commercial value. The latter fund is designed to stimulate industrial research.

Although financial support for research and development by industry has been very meager, some industrial support has been provided for engineering schools and for scholarships. Substantial support for science and technology is provided by sources outside of Brazil, including foreign governments, international organizations, and private foundations. These funds

were distributed over a wide range of disciplines, and a substantial portion was allocated for improving scientific educational programs and libraries. Significant grants have been made to provide equipment for both teaching and research.

The state governments expend far less for research and development than the federal government, but their systems for selecting, organizing, and executing research are highly efficient and their researchers work with greater enthusiasm and freedom from political influences. The states have established state funds for the support of research. The Research Support Fund in the Sao Paulo State is the oldest and largest of the funds. Its scientific director is considered the second most powerful figure in Brazilian science after the president of the CNPq. In recent years this fund has directed a majority of its grants to development-oriented research rather than pure research. The main source of revenue is the state government, which under the constitution of the state is required to allocate annually to the Sao Paulo State Fund 0.5% of the state's income from taxes. The 1969 budget was 14.5 million cruzeiros and the 1970 budget was about 20 million cruzeiros. The State of Rio Grande do Sul has established a similar organization and the State of Guanabara has set up a Support Foundation for Science and Technology financed by a percentage of state revenue.

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

Modern techniques in education are being introduced slowly in Brazilian schools in both higher and secondary levels. Much of the scientific community long has recognized that slow progress in research and development results from the poor organization of school curriculums and teaching methods. The government is attempting to upgrade education at all levels, and in 1970 the Minister of Planning and General Coordination announced plans to allot 24 billion cruzeiros to education during the following 4 years. Some of the improvements in education can be attributed to a long-range program for science education in Latin America undertaken by the U.S. National Science Foundation through the auspices of the AID. Scientific education in Brazil, although improving as more qualified teachers, more funds, and better facilities are provided, is still handicapped by a general shortage of these essentials.

The number of students enrolled as undergraduates in higher educational institutions in 1972 totaled 530,000. This was slightly less than twice the number enrolled in 1968 but still represented only about 2.5% of the population between the ages of 19 and 24. In 1968 the number of students enrolled in engineering courses was 37,500; in medicine, 25,200; and in science, philosophy, and letters, 76,800. Engineering enrollments are increasing at a rate far greater than the growth of the population of the country. The total enrollment of students in science and engineering courses, however, is small for a country with nearly 100 million people.

Educational reforms have been in progress during recent years. Under former President Costa e Silva, and to a lesser extent under President Medici, drastic changes occurred in the higher educational system which have had an adverse effect on the morale of scientists and teachers. In April 1969 approximately 70 professors were retired from the State University of Sao Paulo and the Federal University of Rio de Janeiro by presidential order, and life tenure for college professors was abolished. These changes dealt a blow to the government program to slow the exodus of professional people from Brazil and have hindered programs for encouraging the return of scientists who have left Brazil. The present government has had some success, however, in encouraging the return of important scientists. Some of the most renowned scientists who left Brazil and others who were purged have returned and found working conditions suitable in some of the larger states; for example, many are staffing the State University of Campinas in the State of Sao Paulo.

Scientific education is strongest at the Universities of Sao Paulo, Bahia in Salvador, Rio Grande do Sul in Porto Alegre, and the Federal University of Rio de Janeiro. Engineering education is available at most of the larger public universities, at the ITA, at Mackenzie University in Sao Paulo, and at the Catholic University in Rio de Janeiro. The quality of education in the School of Engineering of the University of Bahia is reportedly good, especially in the Department of Chemical Engineering, although the staff is small. The ITA is a modern facility and offers some of the best technical training in Brazil, but its enrollment is only about 770. The course is of 5 years' duration, and the 150 members chosen for each class are selected by competitive examination from over 1,000 applicants. Emphasis has shifted gradually

at the institute from aeronautical engineering to electrical and mechanical engineering, electronics, mathematics, and physics. A course in nuclear engineering was introduced in 1967 as part of the effort to promote nuclear energy research. Unfortunately, ITA's graduates are not prepared to assume the administrative-technical jobs in Brazilian industry where supervisory ability is more important than research and development capability. Scientific education at the University of Brasilia is of poor quality, and valuable equipment is either in storage or only partially utilized.

Very little formal graduate study is offered in engineering or in the sciences. A master's degree can be obtained in engineering, but students seeking a doctor's degree in engineering must study abroad. With U.S. assistance, the Institute of Chemistry of the Federal University of Rio de Janeiro started postgraduate courses in chemical engineering, with the objective of granting the master's degree and ultimately the doctor's degree in this field. A program leading to higher degrees in physics has been established at the State University of Sao Paulo, and in chemistry at both the University of Sao Paulo and at the Federal University of Rio de Janeiro in a program coordinated by the U.S. National Academy of Sciences. Financial support of graduate programs has increased substantially in recent years; in 1967 about $760,000 of government funds was spent for such programs. The AID provided about $180,000 for the support of graduate work during the same year. Several other foreign countries, including France, the United Kingdom, and the Netherlands, have also contributed support.

Brazilian universities have made attempts to improve the status of researchers and professors. A professional post of researcher, which allows the incumbent to pursue research on a full-time basis, has been created at the university level. Heretofore, the research worker was required to be a professor, and because of the heavy teaching load, he frequently had to neglect either teaching or research. Salaries for professors are gradually being increased but are still inadequate. The State University of Sao Paulo, which raised the salaries of professors to $400 per month in 1967, has set the salary levels followed by the academic community. Governmental and private research facilities are frequently unable to retain qualified research personnel because of low salaries. The CNPq has provided supplementary salary support for a limited number of qualified persons who have a potential for a research career. In 1968, 200 persons received such assistance.

As a supplement to the inadequate training of scientific and technical personnel, many Brazilians have been sent for special training to the United States under scholarship programs or by industrial companies with subsidiaries in Brazil. One procedure is for the companies to begin operation with a staff of American engineers and technicians and to replace them gradually with Brazilians who have been sent to the United States for training. Except for graduates of the School of Engineering at the State University of Sao Paulo and those educated abroad, Brazilian engineers generally do not meet U.S. professional standards. The second 5-year plan of the CNPq (1968-72) has made provision for the education abroad of students seeking higher degrees in scientific subjects. The CNPq planned to grant an estimated 12,000 fellowships during the 1970-74 period.

Brazil has a serious shortage of engineers, technicians, and scientists in most fields except physics, where the supply has exceeded the demand. In late 1967 it was estimated that Brazil had only 1 person engaged in basic or applied research for every 35,000 inhabitants; in 1972 this figure rose impressively to 1 in 18,000, but it still falls short of the needs. In 1967 there were 3,700 engineering school graduates, compared with 2,000 in 1962. In 1968 the teaching of physics at the graduate and postgraduate level was carried out by about 300 physicists. The second 5-year plan of the CNPq stressed the importance of physics and encouraged the updating of equipment and the modernization of facilities. Brazilian geologists appear to be reasonably well trained; they receive training in three or four schools whose geology departments rank with some of the best in the world.

Although scientists and engineers are highly regarded by the population in Brazil, most Brazilians appear to have little knowledge of the contributions that can be made by scientifically trained people. As in other Latin American countries, scientists are underpaid and many of the younger men soon abandon their scientific or academic careers to enter more lucrative fields. The low salaries paid to scientists are an obstacle to the return of Brazilian scientists who work abroad and to the hiring of well-known foreign specialists. In order to reduce the loss of scientific and technical manpower to more developed countries,

Brazil needs to provide scientists with better working conditions, adequate equipment, and higher salaries.

Facilities and laboratory equipment at the various research centers vary from inadequate to good quality depending on the field of activity. There is a general shortage of modern equipment needed to fulfill objectives of most projects. In some of the university research laboratories and science faculties the solid state physics equipment has been rated as only equivalent to that of advanced secondary schools in North America. In a few cases the universities have an abundance of new laboratory equipment, but some of it is deteriorating from disuse. Some of the best facilities and equipment in Brazil, obtained primarily from U.S. Army surpluses, are related to astrophysics research. Brazil's first Triga Mark I reactor is located at the Institute of Radiation Research near the University of Minas Gerais in Belo Horizonte and the equipment used to study crystal defects and isotopes is considered to be of high quality. The University of Santa Catarina's optical physics laboratory is purported to have received some of the best scientific equipment related to the optical industry from the East German company of Zeiss through a coffee exchange agreement. In general, the physics research facilities of the various research centers are judged by Western European and North American standards as poor. To obtain good laboratory equipment, some of the leading physicists find it necessary to smuggle it into the country by using false radiation labels to circumvent the bureaucratic problems. In nuclear and solid state physics laboratories there are small research reactors and accelerators which cannot provide the energy levels achieved in modern research laboratories.

D. Major research fields

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

Research and development on air, ground, and naval weapons is very limited because of an insufficient economic and industrial base needed to support such activity. Still, Brazil's industrial output is the largest of the Latin American countries, and it has the greatest potential among those countries for achieving a viable weapons development and production capability. Progress towards establishing an indigenous research and development capability is the most evident in the aircraft field.

The Brazilian Government is continuing to invest heavily in the development of its aeronautical industry. Factors motivating such action include those of national security which specify the establishment of the largest and most modern air force in South America, the importance of the national airlines to the country's economic well-being, and to the high dependence placed upon air transportation as a whole in the development of the nation's interior.

Supervision over all aeronautical research and development is provided by the Ministry of Aeronautics, and virtually all aeronautical associated facilities are located in Sao Jose dos Campos, in Sao Paulo State. The most important organization for aircraft design and development is the CTA and its subordinate IPD. Aircraft production is the responsibility of *Empresa Brasilerira de Aeronautica* S.A. (EMBRAER), the *Sociedad Construtora Aeronautica Neiva, Ltda.*, and the *Sociedad Aerotec Ltda.* (Aerotec).

Over the years aviation-related activity appeared to center at CTA and IPD. More recently, however, emphasis has been shifting to an expansion of the nation's aircraft production centers; the largest and most important of which is EMBRAER. Aircraft in production at EMBRAER include a Brazilian version of the Italian Aermacchi MB-326 jet trainer and light attack aircraft; the indigenously developed EMB-110 Bandeirante, twin-turboprop, 12-passenger utility transport; and the EMB-200 Ipanema crop duster. All three aircraft are expected to be in full series production for the next several years. An ambitious development program, identified as the EMB-500 Amazona, has been underway to provide a replacement for the U.S. DC-3/C-47 aircraft in service with the Brazilian Air Force. This aircraft was designed as a 40 passenger, short-take-off-and-landing (STOL) utility transport with alternate roles as an assault troop carrier, and naval patrol aircraft. The program schedule of EMBRAER specified a prototype EMB-500 to be test flown in 1974, and series production to be initiated by the mid-1970's. The EMB-500 program apparently has been terminated, however, and discussions are being held to develop and produce a similar type aircraft under a joint program with Argentina. Should a viable program evolve from the discussions, it would constitute the first major cooperative aircraft development/production effort ever to be undertaken by two South American countries.

Work in process at *Neiva* includes the manufacture of light, utility aircraft (similar to the U.S. Cessna 150), an IPD-designed, low-wing basic trainer designated the 6201 Universal, and the development of a twin-engine version of the Universal. The latter aircraft could enter series production by the mid-1970's. Aerotec is completing its production run on the Uirapuru primary trainer for the Brazilian Air Force. Most of Aerotec's facilities are engaged in subcontract production for EMBRAER.

In addition to the limited aeronautical research being conducted by the CTA and IPD, these organizations are responsible for the certification of new aircraft and the training of aeronautical engineers. The IPD has research departments for electronics, materials, armaments, propulsion, and airframes. Brazil is still dependent on the import of foreign engines for all its current and proposed aircraft. The country also is benefiting from the foreign technical assistance received from the French, West Germans, and Americans.

Brazil has a very limited capability for rocket research and development, and an insignificant capability to design and develop guided missiles. Over the years most of the research in the rocket propulsion field has been directed toward meeting the requirements of the country's sounding rocket program. Nevertheless, short-range, unguided rockets have been produced for military applications. These solid-propellant rockets are the single-stage R-108 and R-115, and a more elaborate, two-stage 114-mm rocket. The R-108 and 114-mm rockets were designed primarily for army use, and the R-115 for the navy. Both rockets were developed by the Department of Studies and Technological Research and the *Companhia de Explosivos Valparaibo*, Sao Paulo. Apparently, Brazil is not making a strong effort to become self-sufficient in the field of guided missiles. Instead, it is continuing to purchase needed guided missiles from abroad.

Brazil has an active research program for studying the upper atmosphere, including the ionosphere. The Institute for Space Research at Sao Jose dos Campos is installing an ERTS readout station at Cuiaba, Mato Grosso State, and digital processing equipment to obtain the imagery at Sao Jose dos Campos. The Institute of Space Research has a Bandeirante aircraft equipped for remote sensing at altitudes up to about 20,000 feet. During the past several years a number of research rockets have been locally developed and produced under air force direction. The rockets have ranged from single- to three-stage units, and from pencil size up to 5 inches in diameter. Present development emphasis appears to be on the Sonda series. There have been 11 known launchings of the Sonda-I, five of the Sonda-II, and a Sonda-III reportedly is nearly ready for its initial test launch. Sonda-I is basically a copy of the U.S. Arcas rocket; it was designed by the Directorate of Materials of the Ministry of Aeronautics; development and production were accomplished by the private firm of *Sociedad Aribras Limitada* of Sao Jose dos Campos. Sonda-Ib is capable of lifting an 11-lb payload to an altitude of 43 nautical miles (NM). Sonda-II and Sonda-III are larger rockets and they are capable of lifting 55 lb to 60 NM and 110 lb to 270 NM, respectively. Sonda-II was designed and developed by the Special Products Department of the ITA. Another rocket, the Somfa-I, also is under development and was exhibited in Brazil during Air Force Week 1970 at the Galeaol Santos Dumont airport complex in Rio de Janeiro. Characteristics and purpose of this rocket are unknown.

The primary rocket test range in Brazil is the *Barriera do Inferno* facility located near Natal. In operation since 1965, the site is equipped for launching sounding rockets, and it can accommodate rockets of the U.S. Nike-Cajun/Nike-Apache size. Although much U.S. equipment is in evidence, the test center is staffed and operated by Brazilian technicians.

Brazil and France concluded a 6-year agreement in June 1968 which provides for the establishment of a space tracking station at Fortaleza on the northeastern coast of Brazil. Since March 1970 this facility has operated as a telemetry receiving station for satellites launched from the French National Center for Space Studies, Kourou, French Guiana. Brazil's first satellite communications ground station, inaugurated in February 1969, was built by Hughes Aircraft Co. under contract with the Brazilian Telecommunications Company (EMBRATEL), Rio de Janeiro. This station has been integrated into the multination communications satellite system, Intelsat.

Brazil conducts no significant research and development on ground weapons and support equipment, and research capabilities in engineering, transportation, and quartermaster equipment are limited. For several years Brazil has been conducting some research on armored vehicles. A light tank and half-track vehicle, both apparently of indigenous origin, are in advanced design stages. Also under development are an armored reconnaissance vehicle (EE-9 Cascavel) and an amphibious armored 6x6 vehicle (EE-11 Urutu). Brazil would like to produce at least four variants of lightly armored vehicles: troop carrier, reconnaissance, command, and ambulance.

There is no active program underway to develop naval combatants or support vessels. Further, there is no discernible research being accomplished in ship propulsion, hull design, or other associated research fields. However, Brazilian shipyards have accomplished the licensed production of foreign vessels up to destroyer size, and they are capable of repairing and overhauling all types of naval vessels. Plans call for Brazil to start production of the British Mark-10 frigate in 1973.

2. Biological and chemical warfare (C)

Brazil is not known to have a BW or CW research and development program. Several institutes however, have sufficient scientific personnel and equipment to conduct limited BW investigations if Brazil should decide to embark on a program. The well-equipped and competently staffed Butantan Institute in Sao Paulo is engaged in fundamental research that has a limited CW potential. One example of this research is the extensive work done on snake antivenoms. Research on other natural poisons includes work on spider venom, scorpion venom, and plant poisons.

3. Atomic energy (S)

The nuclear energy program is small and confined primarily to basic research in the universities. Some expansion is taking place, however, and in December 1971 a combined government-private organization, the Brazilian Company for Nuclear Technology, Brasilia, was formed under the CNEN. The CBTN is mainly responsible for certain practical and commercial aspects of nuclear energy, including propecting for and mining of nuclear associated minerals, fabrication and reprocessing of reactor fuel elements, studies of uranium enrichment, and the contracting for and construction of nuclear facilities. The nuclear energy program is under the general direction of the CNEN, headed by Hervasio de Carvalho. A shortage of research personnel in the nuclear energy field has eased somewhat with the return of personnel trained abroad. Three research reactors are in operation. A 5-megawatt thermal (MWt) swimming pool reactor at the Institute of Atomic Energy of the State University of Sao Paulo went critical in September 1957. This reactor has been upgraded to 10 MWt. The Institute of Radiation Research at the Federal University of Minas Gerais, Belo Horizonte, has a Triga Mark I reactor which went into operation in 1960. It normally operated at 30 kilowatts thermal (kWt) but has been upgraded to 250 kWt. A third reactor, a 10 kWt, Argonaut type located at the Institute of Nuclear Energy at the Federal University of Rio de Janeiro, went critical in February 1965. All three of these reactors use U.S.-provided, enriched uranium fuel.

Brazil's basic nuclear program also will benefit from use of a 20-MeV Pelletronic accelerator in operation at the Institute of Atomic Energy of the State University of Sao Paulo. The accelerator, the only one of its kind in the world, will permit more intense, precise, and wider range neutron cross-section studies. Another cyclotron facility is under construction in the Jacarepagua lowlands and is expected to be operational in early 1973; it will be used in isotope production and utilization studies.

There are some small deposits of uranium reserves in Brazil. The main known deposit is located in the Pocas de Caldas area with a reserve of from 1,200 to 2,000 tons of uranium, and a uranium mill may be constructed at that site. Since only little exploration for uranium has been done in the country, the true extent of reserves is as yet unknown.

Although facilities for processing natural uranium to fabricate fuel elements have been established, Brazil has no facilities for producing enriched uranium and is dependent upon imported fuels. A project utilizing ultracentrifuges purchased from West Germany in 1958 apparently was unsuccessful. Brazil has expressed a desire to participate in a multinational gaseous diffusion enrichment plant. Brazil considers itself as a potential site since ample low cost power is available for such a plant.

Brazilian authorities have stated the country's intention to build nuclear powerplants, and a 626-megawatt electrical (net) pressurized water reactor is being built at Angra dos Reis, Rio de Janeiro State. The contract for this reactor was signed 7 April 1972, with completion projected for late 1976.

4. Electronics (C)

Brazil has little capability for electronics research and development, although the government has allotted special funds to the CNPq and its institutes since 1959 to further electronics research and training of university professors in this field. Some electronics research is conducted by the School of Engineering at the State University of Sao Paulo, ITA, and IPD. Limited research is underway on semiconductors, electron tubes, radio propagation, sonar equipment, and magnetic and gravity measurements. The largest electronic research facilities are those of industry, where the emphasis is on product development. The Brazilian Electronics Industry, Inc. (INBELSA),

located at Guarulhos, is an affiliate of Philips of the Netherlands. It has one of the most modern and completely equipped research laboratories in the country and has done research on microwave and multiplexing equipment, tropospheric scatter techniques, electron microscopes, and solid-state circuits. In addition, some efforts have been made to apply automation techniques to the electronics industry.

Although Brazil does not engage in any extensive research on electronic computers, it is concerned with the use and applications of computers in electronic data processing. The government established the Brazilian Association of Electronic Computers in 1961 to promote computer symposiums, lectures, and training courses. The number of computers in Brazil increased from 100 in 1967 to 300 in early 1969 and to 600 in early 1973, almost all of which were acquired from the United States. An IBM study predicts an expansion to as many as 4,000 by 1980. Brazil was planning in 1971 to undertake construction of the first South American computer.

5. Medical sciences (S)

Biomedical research is not a priority area. Most of the support of the Ministry of Health is directed toward preventive medicine and basic sanitation measures. Of the research undertaken, only a small amount has been of good quality. A critical shortage of competent medical personnel exists, and funds for research are limited. Most of the basic medical research is conducted on an individual basis in universities, while applied aspects are pursued by several institutes under the Ministry of Health. The federal government has supported university research programs by establishing centers for research on schistosomiasis, Chagas' disease, and endemic tropical diseases. The Pan American Health Organization (PAHO) has acted as an adviser to the Ministry of Health in studies on nutrition, sanitation, and disease control. A regional medical library in Sao Paulo is supported by the PAHO. The Institute of Microbiology of the Federal University of Rio de Janeiro is supported by PAHO as a center for training of personnel in public health, education, and research in Latin American countries.

Microbiological research is concentrated on the control of such major infectious diseases as schistosomiasis, Chagas' disease, and plague. Some success has been achieved in the intensive research devoted to schistosomiasis. Cooperative research on the elimination of the vector of Chagas' disease is being undertaken by the Natural Products Research Center of the Federal University of Rio de Janeiro, the National Institutes of Endemic Diseases in Rio de Janeiro and Belo Horizonte, and the Institute of Microbiology of the Federal University of Rio de Janeiro. Extensive trials, with Czechoslovak support, have been conducted on the chemotherapeutic effect of nitrofurane compounds on the vector. The Plague Research Center at Exu in the State of Pernambuco is the center for research on this disease. It has shown that wild rodents are the real reservoirs of plague and that the disease is maintained in isolated island-like foci in the country.

Smallpox has been successfully eradicated. Some progress also has been made in the fight to eradicate the Aedes aegypti mosquito, and, with the collaboration of PAHO, national laboratories are preparing vaccine for prevention of jungle yellow fever. Aftosa (foot-and-mouth disease) virus has been grown experimentally for vaccine production at the Pan American Foot-and-Mouth Disease Center in Rio de Janeiro and a pilot plant for vaccine production put into operation at the end of 1972. The center is important in promoting control of the highly contagious disease.

The Belem Virus Laboratory of the Evandro Chagas' Institute has done considerable research on arboviruses. The laboratory is adequately supported and has the potential to develop into one of the world's most important viral research facilities. Its tissue culture laboratory compares favorably with the best anywhere in the world.

The Butantan Institute in Sao Paulo, of the Ministry of Health, is internationally recognized for its research on snake venoms for the production of vaccines. It maintains a large snake farm and produces antivenoms for snake bites. It also undertakes rabies research.

Biochemists employ familiar techniques in the study of cell components and enzymes. Some routine work is underway on the study of the effects of psychotropic drugs on behavior, the biochemistry of disease agents, and protein electrophoresis variations among different racial groups in Brazil. Biochemists are also contributing to the development of chemotherapeutic agents in the control of malaria and schistosomiasis.

Nutritional research is practical. Surveys have been conducted on the prevalence of protein-calorie malnutrition. The Institute of Nutrition in Recife is developing low cost, high protein foods, and is carrying out a biochemical evaluation of the recovery of malnourished children. The CNPq supports research on the effect of pollution on shell fish and other marine organisms.

Research in genetics has concerned the control of ribonucleic acid (RNA) synthesis in giant chromosomes, gene dynamics in indigenous and mixed human populations, and population genetics. The Brazilians have conducted productive research in selected areas of physiology, pharmacology, and endocrinology. They have done basic studies on the physiology of the reproductive tract in women, the utilization of heart valves and pacemakers, cardiovascular diseases, and the association of endocrine function and metabolism. The Institute of Biophysics of the Federal University in Rio de Janeiro has studied the cytogenetic effects of exposure to ionizing radiation and is also studying signal processing in the visual cortex of monkeys and marsupials. A survey has been made of the effects of exposure of man to high background radiation doses in certain parts of the country.

6. Other sciences (S)

a. Chemistry and metallurgy

Although chemical research is a field of moderate activity in Brazil, it is extremely weak when compared with that of the United States or most other Western countries outside of Latin America. Brazil has a large and rapidly growing chemical industry and numerous allied industries which produce petroleum products, pharmaceuticals, paper, and textiles, but only a negligible amount of applied chemical research is conducted. The research, many of the chemists, and the chemical technology required to support the industry are mainly supplied by foreign investors. The State University of Sao Paulo has the strongest and broadest chemical research program in the country. The major areas of chemistry are researched but not in depth. There are three important centers for chemical research: the Institute of Chemistry of the State University of Sao Paulo, the Institute of Chemistry of the Federal University of Rio de Janeiro, and the Department of Chemistry of the Pontifical Catholic University of Rio de Janeiro.

Inorganic chemical research has been restricted largely to fields of interest to the country's atomic energy program. Several chemists have been interested in thorium and rare earth phosphates because of the country's position as a major supplier of monazite sand, the principal source of thorium and rare earths. The Institute of Atomic Energy of the State University of Sao Paulo does research on purification of uranium, analytical problems associated with the nuclear energy program, processing of nuclear materials, and fabrication of fuel elements for nuclear reactors. Other inorganic chemical research is underway in soil chemistry.

Brazil is weak in important areas of chemical research such as organic chemical synthesis, physical organic chemistry, and physical chemistry. A modest effort is underway in the chemistry of natural products, particularly those derived from Brazilian plants and trees, under Professor Otto Richard Gottlieb at the Federal University of Minas Gerais. Very little research is done on organic polymers, synthetic fibers, pharmaceuticals, or other aspects of the synthetic organic chemical industry.

Brazilian research in analytical chemistry has diminished with the retirement of Dr. Fritz Feigl, an internationally recognized authority on spot-test analysis. A little biochemical research is underway at the State University of Sao Paulo and the Federal University of Rio de Janeiro but the work is not significant.

Only a minimal amount of metallurgical research is undertaken, practically all of it directed toward solving production problems. Essentially no basic metallurgical research is conducted. The universities and the Institute for Technological Research, Sao Paulo, do some work on the refining of nonferrous ores. Perhaps the largest effort is devoted to process extractive ferrous metallurgy. The steelworks of the National Steel Company at Volta Redonda engages in studies directed toward product improvement and toward solving production problems. Some of the research has concerned blast furnace practice, the production of medium alloy steels in the oxygen converter, fabrication techniques, and the causes of defects in forgings, plate, bar, and rod. A few ferrous metallurgical and basic engineering studies are undertaken by the steel mills. The CNEN's Institute of Atomic Energy has a number of research programs on the extractive metallurgy of uranium and thorium, fuel element cladding, structural materials for nuclear reactors, and the metallography of uranium and other nuclear metals.

The Institute for Technological Research is the most significant facility for metallurgical research. It is well staffed and equipped and has conducted extensive failure analyses as well as research on extractive metallurgy, foundry technology, the metallurgy of copper and its alloys, corrosion, and stress-corrosion cracking. Although the institute is supported partially by state funds and grants from the CNPq, most of its support comes from industry on a contract basis.

b. Physics and mathematics

Although Brazil lacks the necessary modern research equipment and adequately trained manpower and suffers from shortages of research funds, it has the best potential in South America for conducting advanced physics research in some of the more important subfields. At present, Brazilian physics research is fragmented and shows signs of disorientation with regard to the national goals of exploiting research results to extend the country's technological base. Because the government generously provides encouragement, support, and a high degree of investment in nuclear power development, it has enhanced the potential for good nuclear physics research. Improvements in research in nuclear physics and solid-state physics are evident, particularly at university laboratories and attached institutes. Other areas in which a modest amount of research is underway include atomic and molecular physics, quantum electronics, optics of spectroscopy, and gravitation and relativity.

Brazilians are especially proud of their achievements in the field of nuclear physics, and those involved in its scientific activities receive considerable respect. High-energy nuclear physicists at the University of Sao Paulo and its affiliated Institute of Theoretical Physics probably conduct most of the Brazilian studies related to elementary particles and their interactions. The nature of the high-energy nuclear research involves highly theoretical studies of hadron, proton-proton, pion-kaon, and pion-pion scattering relations. These studies primarily represent work done in leading countries as far back as 10 years ago; however, some of the research involving investigations of the saturation properties in the Fermi quark model and features of the baryon spectrum is fairly modern. Theories concerning the kaon decay parameters are also being investigated. Low-energy nuclear physics research is being pursued at the University of Sao Paulo's Institute for Atomic Energy, which enjoys an international reputation. The research is applied in nature and deals with thermoluminescent responses of fluorites to gamma-ray emission when exposed to a cesium isotope. This work is being done to determine the potential of the fluorites for use in radiation dosimetry. At the Catholic University of Rio de Janeiro, the ground state of cesium isotopes is being studied for information concerning the unified model.

Brazilians are very active in research in solid-state physics and the physics of materials, but much of the work lags behind most advanced countries by as much as 10 to 15 years. A large portion of solid-state physics research occurs at the science faculties or institutes of such universities as the College of Engineering at the Federal University of Sao Carlos, Sao Paulo; the ITA; the Brazilian Physics Research Center, Rio de Janeiro; the State University of Campinas; the University of Sao Paulo; and the Federal University of Minas Gerais. Some of the most impressive activities are concerned with studies of semiconducting properties of naphthalene thermoelectret crystals in connection with evidence of Schottky barrier formations. Various techniques of radiation damage approaches are being used to investigate the production of photochromic centers in cesium-doped calcium fluoride. Energy-level relations are being studied to gain information on the gamma-points of various polytypes of zinc sulphide. Theories concerning the geometry of solids with lattice defects are being studied. Wave functions associated with dilute alloys of the nonnoble-metal base class are being viewed in regard to their core states.

Atomic and molecular physics research is pursued along modest lines at the Brazilian Physics Research Center and the Institute of Theoretical Physics at Sao Paulo. Projects involve both experimental and theoretical evaluations of ionic electronic absorption spectra and the application of the Rayleigh perturbation theory pertinent to the hydrogen atom. Experimental research in atomic and molecular physics involves studies of width and shift of spectral lines of gases in the microwave and infrared regions through use of models for elastic and inelastic collisions. Laser research or quantum electronics is done on a limited scale and by a few select specialists at the State University of Campinas. Their work is concerned with the measurements of carrier lifetimes of stimulated semiconductor lasers. Some phases of spectroscopic optics are being probed at the University of Sao Paulo and the Federal University of Rio Grande do Sul. The research deals with the pressure broadening and shift of lines in the microwave and far infrared regions with the use of the impact theory and the effects of finite time resolutions on the time spectra. The purpose of these studies appears to involve an attempt to gain knowledge on nuclear relaxations. Brazilian scientists have long been known for their extensive theoretical investigations into gravitation and relativity. The major portion of such theoretical investigations is concentrated at the Brazilian Physics Research Center. The efforts are concerned primarily with the general theory of relativity and its involvement with gravitational and electromagnetic fields. Theories are being advanced on the covariant concepts of gravitation.

Research in mathematics is almost nonexistent, and the little that is accomplished is of poor quality. An Institute of Pure and Applied Mathematics, Rio de Janeiro, was established in 1956 under the CNPq to support and stimulate interest in pure and applied mathematics. Its primary mission has been to provide postgraduate training. All of the universities have faculties of mathematics, and the little research undertaken is in the broad areas of mathematical foundations, algebra, analysis, and geometry. Specific subjects of research have included logic, group theory, ordinary and partial differential equations, functional analysis, topology, and differential geometry. There is no effort in applied mathematics, statistics, operations research. However, the Catholic University in Rio de Janeiro gives a Master of Science in computer science and has a research program. The Federal University of Rio de Janeiro and the State University of Sao Paulo are installing computer science programs along with Catholic University in a program coordinated by the U.S. National Academy of Sciences.

c. Astrogeophysical sciences

(1) *Astronomy, meteorology, and upper atmosphere*—Astronomical research is very limited but is increasing. The chief center of astronomical activity, the National Observatory in Rio de Janeiro, is equipped with four medium-size telescopes and makes observations mostly of planets and double stars. The Morro do Volongo Observatory of the Federal University of Rio de Janeiro has made observations of stellar occultations and comets as well as double stars. The observatory of the Institute of Astronomy and Geophysics of the State University of Sao Paulo specializes in positional astronomy and celestial mechanics. The Center of Radio Astronomy and Astrophysics of the Mackenzie University in Sao Paulo operates the Itapetinga Radio Observatory, about 96 miles north of Sao Paulo; the astronomical work has been confined to the study of solar radio emissions. A 13.7-meter radiotelescope is under construction at the observatory. In 1969 an optical astronomical observatory was under construction in the Santana Hills near Porto Alegre, apparently for the Institute of Astronomy of the Federal University of Rio Grande do Sul. The Federal University of Minas Gerais is establishing a new observatory at Serra de Piedade; a 60 centimeter telescope has been purchased from East Germany for installation at the observatory.

Meteorological research is meager, consisting of routine local weather or climatological studies carried out mainly by the Meteorological Service of the Ministry of Agriculture. A modern surface and upper air network has been established by the Superintendency for Development in the Northeast, under the Ministry of Interior, with the assistance of the World Meteorological Organization and the U.S. Agency for International Development. Tropical meteorological research, including studies of easterly waves, is being carried out by the IPD. Balloon launches for Project TWERLE from Natal are being planned. The Space Research Institute is concerned with satellite meteorological research and the development of automatic picture transmission (APT) readout station equipment for receiving meteorological satellite transmissions. A weather satellite APT readout station, under the direction of the ITA, is located at Sao Jose dos Campos.

Brazil also has cooperated with NASA and Argentina in the Inter-American Experimental Meteorological Rocket Network (EXAMETNET). This network aims at integrating, with the participation of other countries, a meridian network to cover both hemispheres; all meteorological data are made available to all members. Launching activities began with firings from Wallops Island in the United States and the *Barreira do Inferno* range near Natal in Brazil in January 1966, and from the Chamical range near Cordoba in Argentina in April 1966. Brazilian participation included assembling and launching a series of meteorological sounding rockets which were provided by the United States. NASA trained Brazilian personnel and lent ground support. In June 1968 a Brazilian-developed and -fabricated meteorological rocket, the DN-6503, was launched for the first time, reaching a height of about 80 miles. In a Brazil-U.S.-German experiment in February 1973, four Black Browdt rockets were launched in connection with the AEROS satellite program.

The Brazilian upper atmosphere research effort is centered at the Barreira do Inferno rocket range, which is equipped to launch short-, medium-, and long-range rockets for meteorological and ionospheric experiments. The first test launching of a Brazilian two-stage rocket, presumably having no payload, was made from the range in April 1965. Since that time, NASA has supplied U.S. rockets, including Arcas and Nike-Cajun rockets, for experiments to study high-altitude temperature, densities, and winds. Other agreements with NASA have concerned studies of cosmic ray effects on the lower D region of the ionosphere, and during 1968 several Nike-Iroquois rockets were launched to measure the influx of meteors between 96 and 256 miles over the equator.

Brazil has engaged in ground-based study of radio propagation and ionospheric electron-density by

means of reception of satellite signals. The research was begun in 1963 and has been carried out at the Brazilian naval base at Natal and the laboratory of the former CNAE at Sao Jose dos Campos. The naval base at Natal has done point-to-point radio propagation research. The CNAE (absorbed by the INPE in 1971) has had a riometer site operating at Natal with equipment provided by the U.S. Air Force Cambridge Research Laboratory to measure ionospheric absorption of radio waves.

(2) *Geodesy*—In 1952 Brazil and the United States concluded a mapping agreement called MAPPLAN through which the United States has provided assistance to and equipment for the Brazilian mapping program. Under this agreement, the military and civilian mapping organizations, including the National Geographic Council and the state mapping agencies, are engaged in an energetic program of geodetic surveying and mapping. In addition, the development of a horizontal datum reference for South America is underway.

(3) *Geology and terrestrial geophysics*—Because of extensive domestic mineral resources, geological work has received considerable emphasis. Much of the work has consisted of preparing geological maps of Brazil and South America, and since 1950 Brazil has collaborated with the U.S. Geological Survey (USGS) in preparing maps of Brazilian iron and manganese deposits. USGS personnel have led various mineral survey teams in Brazil during which Brazilian geologists have been trained in field operations for future work in other areas. Geologists of other countries also have mapped portions of Brazil. French geologists have participated in efforts to locate uranium reserves that can be used economically. The National Department of Mineral Production has embarked on a 10-year mineral exploration program and is making an extensive study of Brazilian geology for long-range planning purposes. In 1968, Brazil and the United States entered into an agreement to cooperate in an earth resources remote sensing program, utilizing artificial earth satellites. Brazil is adopting U.S. gamma ray spectrometric air surveying techniques. A quasi-governmental Mineral Resources Research Company, Rio de Janeiro, has been established, and US$6 million was to be expended in 1971 and $7 million in 1972 in exploring for uranium.

Brazil has a low level of technical competence for research in terrestrial geophysics. The National Observatory, although an astronomical facility, is concerned with both geomagnetic and seismic activity; most of the effort in these fields has been undertaken with U.S. support. Brazil has permanent geomagnetic stations at Vassouras and near Belem and seismic stations at Rio de Janeiro, Natal, and Brasilia. The station at Brasilia, staffed by Brazilians and equipped by the U.S. Coast and Geodetic Survey, is engaged in a project to observe deep seismic phenomena at a "stable station" for comparison with those at an "unstable station" at the Geophysical Institute at Lima, Peru.

(4) *Hydrology, hydraulics, and coastal research*—Brazilian capabilities in hydrologic and hydraulic research are considerably advanced over those of other South American countries because of the scope of research and the availability of a few well-equipped laboratories. Research is mainly of an applied nature and is directed toward increasing hydroelectric output, improving and extending navigability of inland waterways, and improving flood protection. A project along these lines in cooperation with the USGS has been underway for several years in the mouth and upper reaches of the Amazon. Hydrologic research is concentrated on studies of sedimentation, runoff, and variation of annual discharge. In hydraulic research the use of extensive model testing has resulted in successful investigations in changes in river channels caused by variation of flow velocity, in the reduction of silting, and in the prevention of scour around dams. Considerable emphasis is given to the design of intake structures to prevent vortexes and of chute and energy dissipators to prevent sedimentation and erosion in tailraces.

In general the quantity and quality of coastal engineering research surpass those of other Latin American countries. The Ministry of Navy controls and performs most of the work on physical oceanography and coastal hydrography. Coastal engineering research is also conducted at several universities, the most important being the Institute of Hydraulic Research of the University of Rio Grande do Sul in Porto Alegre. Most coastal research deals with problems of littoral drift and sedimentation.

(5) *Oceanography*—Although Brazil has a low capability for oceanographic research, the country's interest in oceanography has increased substantially as a result of the need for improved defense of its long shoreline and a growing awareness of the importance of oceanography. Brazil has emphasized biological oceanography for the development of its marine fisheries but also conducts special projects in marine geology and radiobiology at the Naval Research Institute. The Institute of Oceanography of the State University of Sao Paulo conducts most of the oceanographic research, although the Directorate of Hydrography and Navigation of the Ministry of Navy has done considerable work in biological, physical, and chemical oceanography. The directorate has an oceanographic and geophysical station at Trinidad and operates the 300-foot, 2,300-ton converted sailing

ship *Almirante Saldanha* as a deep sea oceanographic and hydrographic research vessel. Some research also is done by the Institute of Marine Biology and Oceanography of the University of Recife and the Institute of Marine Biology of the Federal University of Ceara at Fortaleza.

A National Commission for Oceanography was established in 1965 to coordinate national programs and represent Brazilian oceanography internationally. The commission also acts as an adviser to the CNPq on oceanographic matters. The president of the commission is Prof. Manoel da Frota Moreira, who is also head of the technical scientific department of the CNPq.

Brazil participates actively in international oceanographic affairs and was host to the first International Symposium on the Oceanography of the Western South Atlantic in September 1964 and to the first Inter-American Naval Conference on Hydrography and Oceanography in September 1965. Both conferences were held in Rio de Janeiro. Norwegian and Brazilian oceanographers conducted a joint oceanographic survey during the latter half of 1967 that extended as far as 300 miles from the Brazilian coast. This investigation was the inaugural cruise of the new 162-foot, 700-ton oceanographic research ship, *Professor W. Besnard*, of the Oceanographic Institute of the State University of Sao Paulo.

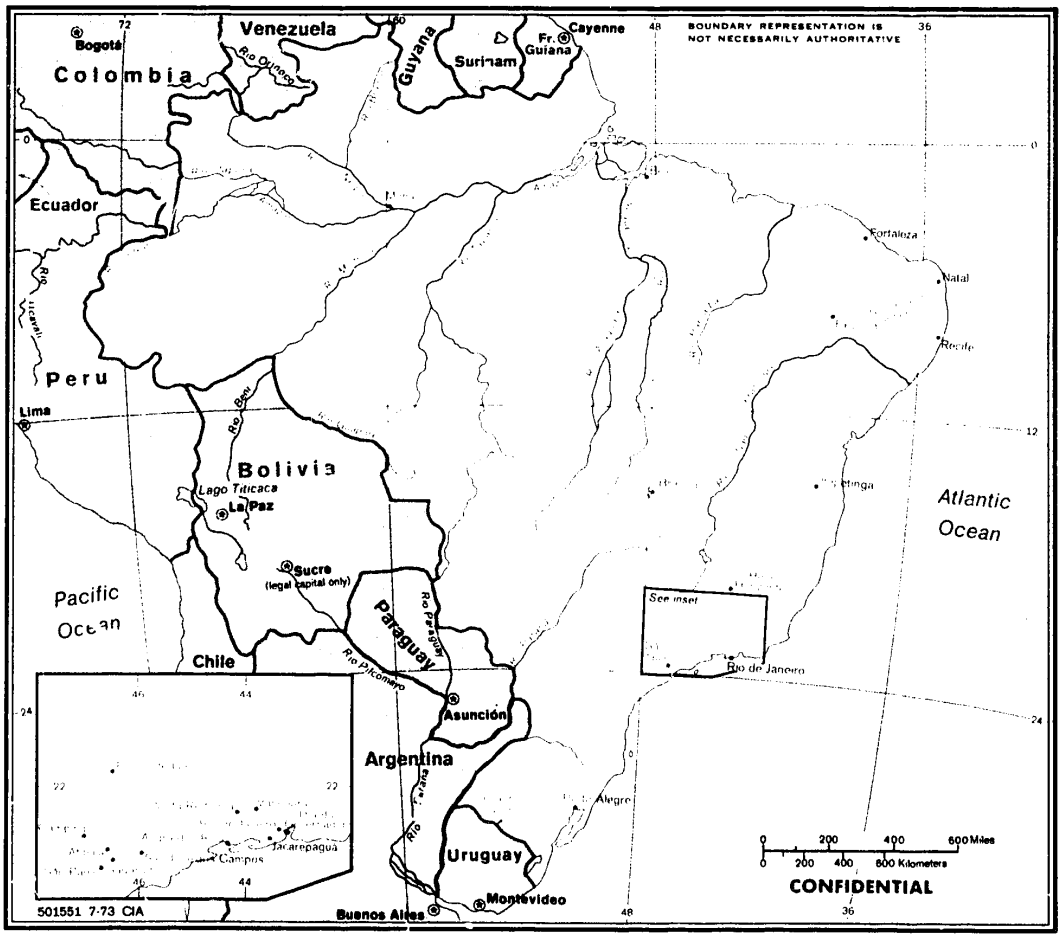

FIGURE 2. Selected sites of scientific activity (C)

Glossary (u/ou)

ABBREVIATION	FOREIGN	ENGLISH
CBTN	*Companhia Brasitura de Technologia Nuclear*	Brazilian Company for Nuclear Technology
CNAE	*Commissao Nacional de Actividades Espaciais*	National Commission for Space Activities
CNEN	*Commissao Nacional de Energia Nuclear*	National Nuclear Energy Commission
CNPq	*Conselho Nacional de Pesquizas*	National Research Council
COBAE	*Commissao Brasileira de Actividades Espaciais*	Brazilian Commission for Space Activities
CTA	*Centro Tecnico de Aeronautica*	Technical Center for Aeronautics
IEA	*Instituto de Atomica*	Institute for Atomic Energy
INE	*Instituto de Engenharia*	Institute of Nuclear Engineering
INPE	*Instituto de Pesquisas Espaciais*	Institute of Space Research
IPD	*Instituto de Pesquisas e Desenvolvimento*	Institute for Research and Development
ITA	*Instituto Tecnologico Aeronautica*	Aeronautical Institute of Technology

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

	COORDINATES	
	° ′S.	° ′W.
Angra dos Reis	23 00	44 18
Belém	1 27	48 29
Belo Horizonte	19 55	43 56
Brasília	15 47	47 55
Campinas	22 54	47 05
Cuiabá	15 35	56 05
Exu	7 31	39 43
Fortaleza	3 43	38 30
Guarulhos	23 28	46 32
Ilha do Governador (*island*)	22 48	43 12
Itapetinga	15 15	40 15
Jacarepaguá	22 55	43 21
Manaus	3 08	60 01
Natal	5 47	35 13
Piedade, Serra da (*ridge*)	7 21	37 20
Póços de Caldas	21 48	46 34
Pôrto Alegre	30 04	51 11
Recife	8 03	34 54
Rio de Janeiro	22 54	43 14
Santana, Coxilha de	31 15	55 15
São José dos Campos	23 11	45 53
São Paulo	23 32	46 37
Vassouras	22 25	43 40
Volta Redonda	22 32	44 07