



Rio de Janeiro, site of the University of Brazil and the Brazilian Center of Research where much advanced work in physics is done. Sugar Loaf Mountain, perhaps Brazil's best-known landmark, towers over the city.

physics in SOUTH AMERICA

By G. L. Brownell

THIS report is based primarily on observations made during a three-month trip to South America during the summer of 1951. Obviously, the task of presenting a complete and comprehensive survey of physics in South America with the many ramifications in the economic, social, and political patterns of these countries cannot be undertaken with this experience and in this space. However, the evidences of vigorous development in physics and other basic sciences in South America have been sufficiently impressive to me to warrant recording my impressions of some of the leading laboratories in the hope that they will be of interest to other physicists. I am certain that in a relatively few years physics in South America will have developed to such an extent that physicists here will not only find it of interest, but will find it scientifically imperative, to maintain close contact with their colleagues on the opposite side of the equator.

The opportunity for observing various laboratories and centers of training in South America came about through participation in a medical project for the study of iodine-deficient goiters in Mendoza, Argentina, a region of intense endemic goiter. This project, conceived by Dr. James H. Means of the Massachusetts General Hospital, was sponsored jointly by the Massachusetts General Hospital, Harvard Medical School, and the University of Cuyo, and was carried out jointly by leading Argentine medical investigators headed by

Dr. Hector Perinetti of Mendoza and Dr. Enrique B. del Castillo of Buenos Aires, and a group from the United States consisting of Dr. John B. Stanbury, director of the Thyroid Laboratory at MGH, Dr. Douglas Riggs, Assistant Professor of Pharmacology at HMS, and myself. Generous support was given by the Rockefeller Foundation, the Guggenheim Foundation, the Loomis Foundation, and the Argentine Government. The Rockefeller Foundation also supplied funds which allowed us to visit laboratories and give lectures at many of the leading South American scientific centers. It was during these visits that most of this material was obtained.

South American scientists are extremely interested in exchanging information with their colleagues in the States and obtaining information on the latest developments in their scientific fields. This interest, together with the inherent hospitality of South Americans, made this trip an extremely pleasant experience for all of the group, and I am sure that many other visitors have expressed the same opinion. Physicists in the Western countries of South America commented frequently on the stimulating series of lectures on cosmic rays given by Dr. Serge Korff during the preceding year, and biophysicists in Buenos Aires express similar favorable comments on the visit of Dr. Edith Quimby. The hos-

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pitality of South Americans is legendary and extends even into the scientific laboratory. The cordial interest in visitors at these laboratories makes one a little self-conscious of the somewhat mechanical reception that often greets visitors to large laboratories here in the States.

A few fairly obvious comments on the general problems facing scientists in these countries may be in order. First, compared to the United States, the experimental phases of the fundamental sciences in South America are in their infancy. However, there are many evidences that the infant is in an exceptionally healthy state; and, considering the rapid development of experimental sciences in the United States over the past ten or twenty years, there is good reason to believe that this infant may develop in a relatively few years into an active competitor. Experimental science, even of a fundamental nature, is of necessity linked to the industrial development of a country. Fundamental science must be supplied in good measure by technical schools whose primary function is to train engineers and technicians to further the industrial level of the country. Only with the relatively advanced technology will industry directly stimulate research and training in the fundamental sciences by providing problems and positions for highly trained scientists. Perhaps the most striking trend in South America is the rapid development of all types of industry. This development, particularly as in Brazil, resulted from private enterprise and from such government-sponsored agencies as the Corporation for Development of Industry in Chile. Partially as a result of this development, a number of schools offer excellent training in the engineering fields giving a broad course in applied and pure science, including physics, chemistry, and mathematics. Their curricula compare favorably with those of similar institutions in the United States, and in fact may tend to be somewhat broader and more comprehensive. On the other hand, only a few of the most advanced institutions offer advanced courses and opportunity for research in physics.

Theoretical physics is a well-developed science in South America, although on a limited scale. The study of advanced physics was introduced by German and Italian theoretical physicists, such as Bose and Wataghin, and much of the influence in physics training has been European. This includes, in addition to the influence of German and Italian physics, that of France and of Spain. It is quite common to find French texts in many of the schools, and in fact some of the scientific articles are written in French. It is, nevertheless, probably safe to say that the primary influence and source of collaboration of the few laboratories of experimental physics is the United States. A few specialized fields of experimental physics, such as astrophysics and biophysics, have been developing in most of the South American countries, and here again the influence is to some extent European.

The following sections are devoted to impressions obtained in visiting some of the leading schools and

laboratories in the following five countries: Peru, Chile, Argentina, Uruguay, and Brazil. These countries are typical of those in South America possessing the highest level of technology, and consequently physics training. The order is not intended to be indicative of scientific level, but reflects the geographical route: the trip South being by the West coast, and the return route along the East coast.

PERU. On arriving in Lima from Miami, one has the feeling that one has come to another world rather than another country. The old-world charm of the city with its churches, schools, and public buildings of exquisite Spanish architecture and a tropical setting of palm trees and bougainvillea provides a scene which defies description. Perhaps even more dramatic are the arid plains which encircle the irrigated parks and streets of the city and stretch toward the towering snow-capped Andes in the West. However, in addition to the old-world charm, Lima exudes a feeling of quiet prosperity. Undoubtedly one reason for this apparent prosperity is the rich mineral and petroleum deposits in Peru, a fact substantiated by the price of gasoline at about five cents a gallon.

Training in physics in Peru is concentrated in Lima and is limited to courses for engineers. Here three institutions offer courses in physics to engineering students: The National School of Engineering (Escuela Nacional de Ingenieros), the University of San Marcos, and the Catholic University of Peru. Through the courtesy of Professor Antonio Tarnawiecki, I had the opportunity to visit the National School of Engineering and talk to some of the faculty. The school itself consists of a group of modern buildings housing efficient laboratories and classrooms. Students enroll for a five-year course in civil, electrical, petroleum, architectural, construction, or sanitary engineering. The level of student ability is maintained by rather stringent admission examinations. Only 200 candidates from 800 are accepted each year. The school maintains a pre-engineering school for about 500 students, and the top 100 students enter the first year without taking admission exams.

During the first year, students take a general course which includes three hours a week of physics lectures and one afternoon of demonstration. In the second year, students in each of the courses receive specialized courses in physics with approximately the same time allocation. Although these are the only formal physics courses, students in some specialties receive advanced training in electricity, heat, and other physical topics.

The organization of the University of San Marcos (Universidad Nacional Mayor de San Marcos) is much the same as that of the National School of Engineering. Physics is taught in the School of Physical Sciences and Mathematics (Escuela Instituto de Ciencias Fisicas y Matematicas) under Dr. Antero Bueno. The Catholic University of Peru also gives courses in physics.

There are a number of reasons why independent re-

search in physics and other pure sciences is difficult at these schools. The organization of the schools is such that training in physics, other than that of the first year, comes directly under the engineering specialty. Thus, there is no central department of physics to organize and direct investigations. Another reason is simply lack of funds to obtain equipment for research. A third, and perhaps even more important reason is the common practice throughout all of the scientific fields of holding two or even more positions simultaneously. This results primarily from the low institutional salaries which make it imperative to obtain other sources of income. Thus, a professor at one of these schools might also have a position in an industrial laboratory and in addition carry on a consulting business. This circumstance places a great demand on the time of the scientist and greatly limits the time available for independent research.

In addition to a general awakening of interest in the basic sciences, there are a number of concrete indications that the situation will be improved. There is a strong movement underway in Lima to organize the basic sciences into departments similar to those found in most technical schools in the United States. Also there is a definite trend towards full-time positions for teachers and workers in these schools and increased salaries. These are undoubtedly forerunners of greatly increased activity in teaching and research in basic sciences.

The Institute of Andean Biology (Instituto de Biología Andina), under the direction of the University of San Marcos, has been aided by the Carnegie Foundation. It is located in the Andes at Morococha, a short distance from Lima. The work here is primarily in the medical fields studying the effects of high altitude on humans and is under the direction of Dr. Hurtado. This laboratory was the scene of a recent study of red cell metabolism at high altitudes with radioactive tracers by a group from the University of California under Dr. J. H. Lawrence.

Dr. Monge directs a similar institute at Huancayo, a short distance from Morococha, but at a higher altitude. The Geophysical Institute of Huancayo (Instituto Geofísica de Huancayo) under the direction of Dr. Albert A. Giesecke, Jr., is also located here. This laboratory, under the direction of the University of San Marcos, is carrying on investigations in a wide variety of geophysical fields such as terrestrial magnetism, atmospheric electricity, sun spots and solar prominences, and cosmic rays.

CHILE. From Lima the group went by plane to Santiago, Chile. Santiago possesses much of the picturesqueness of Lima, but in addition shows more evidence of a rapidly increasing industry. The government-sponsored Corporation for the Development of Industry has aided greatly in this progress. Outside of Santiago, the city of Huachipato is a rapidly growing steel center. The city of Santiago offers many advantages as a place to live and work. Although much of

Chile is arid, the city and some of the land about it are green and fertile due to streams arising in the Andes and to irrigation. The residential sections are particularly attractive and the business sections are modern and active. Magnificent ocean resorts, such as Vино del Mar, are located a short distance from Santiago, and skiing enthusiasts can find excellent ski slopes at Fareloness, located in the foot hills of the Andes a few hours from the center of the city, and at Portillo, a world-famous ski resort, located high in the Andes near the Argentine border.

In Chile, physics research and training is centered in Santiago, Concepción, and Valparaíso. The University of Chile, Catholic University of Chile, University of Concepción, and the Catholic University of Valparaíso offer training in physics in somewhat the same manner as in Lima. Physics research workers here face much the same problem as at similar schools in Peru; but here again, there is a strong movement underway to centralize training in physics and provide full-time research work.

I took the opportunity of visiting some of the laboratories at the University of Chile through the courtesy of Dr. Pablo Krassa, retired dean of the faculty of physical and mathematical sciences of the University of Chile. Dr. Krassa's primary interest has been in physical chemistry, but he has had, and still maintains, an interest in all of the activities of the faculty. At the present time, physics is taught in this faculty under Professor Gabriel Alvial. The activities of the department are primarily concerned with training for the courses in physics for engineering students. The laboratories were particularly interesting because of the ingenious use of limited experimental material. Professor Constantine Jacoby, the physics laboratory chief, was responsible for most of this equipment. Besides the faculties of physical and mathematical science, physics is taught in the faculties of philosophy and education under Professor Naum Joel and also in the faculties of pharmacology and medicine. The courses run somewhat parallel in these faculties.

The University of Chile maintains a refractor telescope of 60 cm diameter at an observatory on Colorado Mountain (Cerro Colorado) at an altitude of 3,300 meters. Professor Federico Rutllant is the director of this observatory. Professor Gabriel Alvial has done considerable work in cosmic rays and has made observations on high altitude cosmic-ray phenomena at Cerro Colorado. With Dr. Rutllant is Dr. Louis Liboutry, whose primary field of investigation is astrophysics. The observatory of the Catholic University is located in the city of Santiago, where Professor Heilmair directs the work in astronomy.

ARGENTINA. From Santiago, the group went to Mendoza, Argentina, the scene of the investigation of endemic goiter. Although Mendoza is located only a few hundred miles from Santiago, the highest ranges of the Andes lie between these two cities. The trip by train takes more than twenty hours, but is rewarding

in magnificent views of the Andes. The plane trip between these two cities takes approximately forty minutes and is equally spectacular. Perhaps the highlight of the plane trip is the view of Mt. Aconcagua, which at 7,000 meters is the highest mountain in North and South America and towers well above the cruising level of the Convairs used by Aerolineas Argentinas for this flight. The region about Mendoza is at least as arid as the plains along the Pacific Coast. The water used by the cities and for irrigating the vast vineyards is derived almost entirely from the few streams which flow from the Andes. The fact that these waters from the melting snow have not had the opportunity of leaching out minerals from the soil undoubtedly contributes to the iodine deficiency of the people of this vicinity. The primary industry of the region is the production of wine, and the vineyards stretch out on all sides of the city. The city of Mendoza consists primarily of two or three story buildings, many painted white or in light colors. This architecture, together with the clear, sunny skies, gives an impression faintly resembling that of a Southwestern town or city in the United States. The danger of earthquakes up until recent years has been a deterrent to the construction of larger buildings. In 1861, the city of Mendoza was completely destroyed by an earthquake. However, in recent years the advent of earthquake-proof structures has permitted construction of several larger buildings of seven or eight stories, among them being the Central Hospital where our research was carried on.

Seven weeks of the trip were devoted to the investigation carried on at the Central Hospital. A preliminary report of this investigation has appeared in the February 1952 issue of the *Journal of Clinical Endocrinology*, but the data is still being prepared for the final report. As an adjunct to this investigation, the first use of radioiodine in Argentina was made. In general, the investigation consisted of chemical analyses of iodine intakes and iodine blood levels in patients having goiters, and in the study of the dynamics of the iodine metabolism in these patients with radioactive iodine. The equipment was brought from the United States and the radioactive iodine applied was from Oak Ridge. Perhaps the most striking point about this research, particularly to those not primarily interested in medical problems, was the complete cooperation on the scientific level by investigators from two countries. I feel quite sure that this cooperation would exist in any similar scientific undertaking regardless of the field of interest or the countries involved. In our case, this cooperation extended even beyond the scientific level as evidenced by the willingness of the Argentine air force to fly in special equipment and drugs from Buenos Aires, and by various drug companies to provide special drugs. Indeed, the spirit of helpfulness which we encountered in every phase of our project was most heartening to everyone in the group.

The life of a scientific investigator in Mendoza is similar to that of scientists in many other Spanish-

speaking South American cities, and differs considerably from that of his colleagues here in the United States. In general, the scientists and technicians in the South American cities put in much longer hours than we are accustomed to. It is not uncommon for people to work from eight in the morning until eight thirty or nine in the evening. The fact that the scientist may have several positions to attend to means that his day is filled with appointments, routine, and moving from one location to another. However, perhaps the greatest difference is in the eating habits of South Americans as contrasted with those here. Breakfast is the equivalent to coffee and a doughnut here in the States. However, in place of a doughnut one finds media-lunes, a sweet roll shaped appropriately in the form of a half moon. However, this meager breakfast is more than compensated by a lunch, which by all American standards would be considered an elaborate dinner. This meal is one of the social events of the day, and is usually partaken in the home and followed by a period of relaxation from the day's work. The evening meal usually begins at eight thirty or nine o'clock; and if the lunch corresponds to a dinner here, this meal would most nearly correspond to a banquet. However, it would be most inappropriate to imply that the primary social activities of South Americans are related to eating. In general, South Americans are an extremely cultured people. It is necessary only to say that the comparatively small city of Mendoza sponsors a concert orchestra and an active ballet group and many other cultural and educational activities. These are carried on primarily in conjunction with the University of Cuyo, a regional university with some departments in Mendoza.

To return to physics, training and research in this field in these small cities of Argentina, such as Mendoza, are quite limited. However, at the University of Cuyo an attempt is being made to establish a department in the natural sciences, and Dr. Otto Gamba, a physicist on the Argentine Atomic Energy Commission, is preparing courses at the University. In addition, he is setting up a small laboratory for nuclear research, equipped primarily with French scaling apparatus to be used for training in experimental physics. Dr. Gamba studied in France, and until recently was at the University of Illinois working with Dr. Sherwin. Most of the engineering sections of the University of Cuyo were located at San Juan.

From Mendoza we had the opportunity to visit Bariloche, a region in Southern Argentina or Patagonia noted for its Swiss-like scenery and its mountains, lakes, and forests. In addition to its scenic beauty, the spot particularly interested us because it was the location of the largest laboratory of experimental science in Argentina, directed by Dr. Ronald Richter, and located on Huemul Island. This laboratory is, of course, under the direction of the Argentine Atomic Energy Commission, which is headed by Col. Enrique Gonzales, a close friend and associate of General Peron. Col. Gonzales' son, Capt. Gonzales, serves as a liaison offi-

cer between the Atomic Energy Commission and the laboratory. The laboratory itself is on an island on Lake Nahuel Huapi and located near the town of San Carlos de Bariloche. The work at the laboratory is restricted and close security measures are kept.

Although it was impossible to visit the laboratory, we had an informal discussion with Dr. Richter. The work at the laboratory, directed by Dr. Richter and four German and Austrian associates, is said to be devoted entirely to thermonuclear research. Dr. Richter stated that the work was aimed solely towards the production of energy for industrial purposes, and expressed optimism that concrete results will be forthcoming in the near future. He also expressed willingness to share these results with other countries interested in combating the menace of communism. Although Dr. Richter did not give any specific information on his development, he indicated that his program of research was unrelated to any previous work in this field and to such speculations as concern the thermonuclear reactions in stellar production of energy. Laboratories are being developed at other locations in Bariloche for research in biology and medicine, and Dr. Carlos A. Francetti, a radiologist who has spent some time in the U.S.A., heads the Biology Division. It is perhaps unfortunate for physics in Argentina that the work at these laboratories has little or no integration with other physics activities. It might be assumed that as results are published, security measures will be relaxed to a degree where Argentine students and other scientists might cooperate more fully in the effort. This would give a tremendous impetus to experimental physics in the country.

From Bariloche, we were flown to Buenos Aires, and were immediately submerged in an involved schedule of social and scientific events, climaxed by a conference with General Peron. Although the primary topics of discussion were in the medical field, concerning the Mendoza Project and other similar medical projects, some consideration was given to the use of the sixty-inch synchrocyclotron which was being purchased from Philips in Holland. This machine, which will produce 30 Mev deuterons, is scheduled to arrive in Buenos Aires in 1953, and it is planned to use it at least partially for the production of radioactive isotopes for medical research. A former drug house, the Laboratory Mansone, is being converted to a laboratory to house this machine and various physical and chemical facilities. Dental research is of considerable interest to General Peron and others in the governmental circle, and the machine will undoubtedly be used for the production of the short-lived fluorine isotope for dental research in the medical schools of Buenos Aires. The physicist who will be associated with this laboratory is Dr. Marco Poggio, who until recently was with the University of La Plata.

The Institute of Physics, at the University of Buenos Aires, is the leading center of physics in Buenos Aires, and perhaps in Argentina. It is one of two institutions which offer a doctorate in physics. I visited the labora-

tories and classrooms through the courtesy of Dr. Teofilo Isnardi, the director.

With Dr. Isnardi is Dr. Ernesto E. Galloni, one of the leading experimental physicists in Argentina. Dr. Galloni is currently engaged in research in x-ray diffraction and crystallography, electron diffraction, and other problems in solid-state physics. Among his associates are Dr. Mossin Kotin, Dr. McMillan, and Professor R. Busch. Dr. Galloni is also president of the Argentine Physical Society, founded in 1943 by Drs. Beck and Gaviola. Dr. Jose B. Collo is interested in the problems of theoretical physics, and Dr. J. F. Westerkamp is one of the leading young theoretical physicists in Argentina.

Other theoretical physicists at the Institute include Dr. O. Varsavsky, Dr. J. J. Giambiagi, and Mr. M. Bunge. Professors A. Gonzalez Dominguez and L. Santalo are mathematicians working on physical problems. Giambiagi and Westerkamp are engaged in some problems of quantum electrodynamics, Varsavsky in quantum statistics, Bunge in quantum theory, and Gonzalez Dominguez is working on a rigorous justification of the mathematical formalism of Feynman and Dyson. Dr. Ricardo Gans teaches this faculty and is also connected with the Radio-Technical Institute. His interests are electromagnetic theory, radio communications, and antenna design. Drs. Cicchini and Matkov have done work in cosmic-ray research at the Institute. This work has consisted primarily of the study of film exposed at a high altitude station located at Los Andes in the Andes south of the city of Mendoza. A group of young physicists have been doing work with nuclear emulsion, guided by Professor Wirtz of Goettingen who was in Argentina last year.

The Institutes of Physics at the Universities of Buenos Aires and of La Plata are the only Argentine institutes which offer doctorates. Students at these institutes study for approximately five years to obtain a license in physics, and no more than ten students receive their license each year at both schools. These students receive at least four courses in higher mathematics: real functions, analytical functions, differential equations, differential geometry, or probability and statistics. In addition to elementary courses in general and experimental physics offered during the first years, together with elementary mathematics courses, the students take courses over a period of three years in advanced physics. Two courses in theoretical physics are taken during the fourth and fifth years, in addition to a course in physical chemistry. After the license, approximately two semesters are required to obtain the right to do doctoral work. Work for the doctorate entails independent research over a period of many years. Because of the rather rigorous requirements, an award of a doctorate in physics is a rather rare event. In fact, only about twenty-five doctorates in physics have been given in Argentina.

Other institutions in Buenos Aires include the Radio-Technical Institute, which is under the direction of Dr. Gans. With Dr. Gans at this institute, is Dr. Manuel

The Brazilian Center of Physical Research (Centro Brasileiro de Pesquisas Físicas) is under the direction of Dr. C. M. G. Lattes, well known in this country for his work at Berkeley with artificially produced mesons. The Center's electronics shop is shown on the opposite page.

Photos by L. Lima



Bemporad who is interested in various problems in theoretical physics and antenna design. Dr. Fidel Alsina Fuertes is at the Naval School in Buenos Aires and his interests are in the general theory of relativity. Some of the members of the faculty of the University of Buenos Aires also teach at the Naval School.

Because of limitations on time, we were unable to visit one of the leading centers of science in Argentina, the University of La Plata. This university has the distinction of being the first institution to offer courses in advanced physics in South America. About 1912, Dr. Bose and Dr. Gans were invited to the University to inaugurate a series of courses on topics of advanced physics. Among the students taking these courses during the first year, four figure predominantly in the development of physics in Argentina. Dr. Loyarte taught physics for many years at the University of La Plata and was the Director of its Institute of Physics. Dr. Teofilo Isnardi was professor at La Plata, and then moved to Buenos Aires as Director of the Institute of Physics. Dr. Hector Isnardi was research professor at La Plata until 1947 and Dr. Jose B. Collo was professor in the Navy School and is now at the University of Buenos Aires. An engineer, Dr. Ucha is at the present time director of the Institute of Physics at La Plata. Considerable work is being carried on at the astronomical observatory under Dr. Luis Livio Graton, formerly connected with the Mt. Wilson Observatory. Dr. Graton's interests are in the problems of astrophysics. Dr. Antonio Rodriguez, who was for some years at Edinburgh with Max Born, is interested in problems of the liquid state; and Dr. Jose Balseiro, one of the leading young theoretical physicists in Argentina, is currently studying at Manchester under Professor Rosenfeld.

The largest observatory in Argentina is located at Cordoba, but is independent of the University of Cordoba. The construction of the telescope at Bosque Alegre, Cordoba, was directed primarily by Dr. Enrique Gaviola, who studied at Berlin University and worked with Dr. Strong at the California Institute of Technology. Dr. Gaviola has been interested in problems of lens design and coating, and has also been interested in spectroscopic problems such as the metastatic state of mercury. His successor at Cordoba is Dr. Ricardo Platzec, a specialist in optics. Dr. Damien Canals Frau has done considerable experimental work in connection with cosmic rays and optical filters and is interested in problems of theoretical physics. Dr. Guido Beck, a noted theoretical physicist now in Brazil, was associated with the observatory for many years.

The role of the government in Argentine scientific institutions is very important. Essentially, all schools and laboratories come directly under some branch of the government. The pros and cons of such an arrangement could be argued indefinitely, and such arguments are not unknown in our country. However, there is very little likelihood that autonomous institutions will develop to any extent in Argentina, at least in the near future. It is possible that as the industrial development continues, industrial laboratories will produce facilities and personnel for basic research. However, the immediate problems confronting the development of physics deal primarily with the university-government relation, and these problems are similar to those of other South American countries. Increased academic freedom, salaries, tenure, and full-time positions for staff members and increased appropriations to the universities for experimental research would, without a doubt, result in vastly accelerated progress in the basic sciences.

URUGUAY. The trip from Buenos Aires to Montevideo was made by boat across the mouth of the Rio Platte. Montevideo is a beautiful city, extending for miles along the mouth of the Rio Platte and touching the salt water of the Atlantic Ocean. The shoreline presents a magnificent spectacle of resort hotels and summer homes. The city is dotted with parks and statues; perhaps the most famous is the statue depicting the early settlers in a covered wagon drawn by oxen. The largest park in the city is called Roosevelt Park in honor of Franklin Delano Roosevelt. Politically, Uruguay has been called the Switzerland of the Americas. Certainly this country is the most democratic nation of the continent, if not of this hemisphere.

Physics training in Montevideo is concentrated in the Faculty of Engineering of the University of Montevideo under the direction of Dr. Walter Hill, whose laboratories are located in the modern and functional Engineering Building which has recently been completed. Dr. Hill is interested in a number of phases of experimental and theoretical physics. One of his recent works



is concerned with the determination of the content of radioactive materials in fossils of various ages. Dr. Hill also carries out work at the Laboratory Ancap, an industrial laboratory operated by a group of industries, including alcohol and Portland cement. The work here consists of industrial development and control.

Physics is also taught in the faculty of humanities and sciences of the University of Montevideo by Dr. Felix Cernuschi, who was formerly at the University of Cordoba. The students at this faculty are primarily those studying to be secondary school teachers.

BRAZIL. The next stop scheduled on our itinerary was São Paulo. However, due to inclement weather, our plane could not land and we had to continue on to Rio. This was one of the real disappointments of the trip, for São Paulo, in addition to being one of the fastest growing cities in the world, is also an

active and rapidly developing scientific center. Perhaps the most important date in the development of physics in Brazil is 1934, when Dr. G. Wataghin was invited from Italy to the University of São Paulo. Dr. Wataghin stayed at São Paulo until 1948, and during this time he and his group made the first studies of the properties of cosmic-ray penetrating shower. This work was continued after Wataghin left by H. Meyer, G. Schwachheim, and A. Wataghin, Jr. The director of the physics department of the University of São Paulo at the present time is Dr. Marcelo Souza Santos. Dr. Souza Santos has charge of the operation of the betatron at the University, while Dr. O. Sala, another young physicist who has had graduate training in the United States at Princeton, is supervising construction of a Van de Graaff generator. Among other members of the department, Dr. J. Tiomno is working in theoretical physics, and Dr. Hans Stammreich is working in spectroscopy.

Rio de Janeiro is considered to be one of the most beautiful cities in the world, and the city lived up to our expectations in every way. Indeed, one might wonder whether in this semitropical setting of parks and beaches scientists could find the incentive to spend long hours in the laboratory. That this incentive exists is apparent from the tremendous amount of activity and enthusiasm in all branches of scientific research. One of the centers of advanced training and research in physics in Rio is the physics department of the University of Brazil, which is under the direction of Dr. Costa Ribeiro, scientific director of the National Research Council of Brazil. With Dr. Ribeiro, are Doctors C. M. G. Lattes and J. Leite Lopes. Most of the training in advanced physics in Rio is carried out in this department. A considerable amount of independent research is also done.

Perhaps the most interesting physics laboratory in Brazil and in South America is the Brazilian Center of Physical Research (Centro Brasileiro de Pesquisas Fisicas). This laboratory is closely associated with the University of Brazil, but is a separate entity and a private institution supported by grants from industry and the government. The director of the Center is Dr. C. M. G. Lattes, a former student of Wataghin at São Paulo and known for his work with the Bristol group on the study of cosmic-ray mesons and in the production of artificial mesons at the Berkeley Radiation Laboratory. With Dr. Lattes is Dr. J. Leite Lopes, who has had graduate training in the United States at Princeton and has achieved considerable reputation as a theoretical physicist, particularly in meson theory. Approximately eight other associates complete the staff. The close association between the Center and the University of Brazil is maintained primarily through Drs. Lattes and Lopes.

The laboratories at the Center are remarkably well equipped and are reminiscent of research laboratories in many of the large universities here in the States. Much of the equipment has been obtained from outside sources, but a large amount has been, and is being,

constructed at the Center. The building housing the laboratory is efficient though small, and plans are being completed for the construction of a new laboratory building which is to be one of the first in a proposed "University City" located a short distance from the center of Rio. It is planned eventually to relocate all of the activities connected with the University of Brazil to this site. A one-Mev Cockcroft-Walton generator is on hand to be set up in this building when it is completed, and the National Research Council of Brazil is in negotiation with United States firms for the purchase of a cyclotron for the laboratory. In the meantime, emphasis is given to work on cosmic radiation as a somewhat more indirect but equally important method for studying elementary particles and their mutual interaction. At the present time, investigation of cosmic-ray showers is being undertaken both at great depths in the mines of Morro Velho and at high altitudes at the observatory of Chacaltaya in Bolivia and Morococha in Peru. A high altitude laboratory for permanent cosmic-ray work is now being set up in the Bolivian Andes at the Chacaltaya Observatory in cooperation with the University of La Paz. Associated with this work at the University of La Paz are Dr. Angel Escobar, who spent the last two years at MIT, and Dr. Alfredo Hendel. Photographic emulsions have been used a great deal in cosmic-ray and other studies, but counting equipment is being developed and will be used to a greater extent in the future. In this connection, a Wilson cloud chamber and a wide variety of counting apparatus have been constructed at the Center.

The caliber of work at this laboratory is indicated by the visitors who are currently studying, working, and teaching there. Dr. Guido Beck, formerly connected with the Observatory at Cordoba, is currently working at the Center on problems in theoretical physics. Dr. R. P. Feynman of the California Institute of Technology is now spending a year there, and Dr. Occhialini is soon to arrive for a two to three year stay. Dr. M. Schein is another of the noted visitors and Dr. G. Molière, a well-known cosmic-ray theoretician from Germany, was expected early in 1952. The Center is fortunate to be one of the first institutions to be engaged in the Unesco program for exchange of scientific personnel. Under this plan, three scientists from the Center may study at other laboratories throughout the world, while three foreign scientists spend a year at the Center. At the present time, Dr. U. Camerini from the Bristol cosmic-ray group and Dr. G. Hepp from the Philipps Electronic Laboratories are working at the Center under the Unesco program. Unesco has also organized a symposium on physics to be held in Brazil in July of 1952. As with many other South American scientific institutions, the Center would very much appreciate receiving reprints of articles and available lecture notes from their colleagues in the United States in order to keep abreast of latest developments here. The address is: Centro Brasileiro de Pesquisas Fisicas, Avenida Pasteur 250, Rio de Janeiro, Brazil.

At other locations in Rio, physics training is given at

the National Institute of Technology under Dr. B. Gross, a well-known scientist in world physics councils. The Catholic University of Rio de Janeiro also has an active physics department. Father F. X. Roser of this university was in Dr. Schein's laboratories in Chicago during 1949 and 1950 and has been in Stanford this year. He will be in charge of a laboratory on nuclear induction when he returns to Brazil.

One of the leading laboratories in biophysics is the Institute of Biophysics of the University of Brazil. Dr. Carlos Chagas, also well known in international scientific circles, is director of this well-equipped laboratory. Current investigations include study of electric eels, use of very soft x-rays for localization of elements in tissue, electrophoretic study of snake venoms and other compounds, and applications of radioactive materials to biological problems.

The scientific cooperation between investigators in Brazil and the United States is evidenced in every phase of scientific research. Many of the young physicists, including Lattes, Souza Santos, Leite Lopes, O. Sala, and J. Tiomno, have had graduate training in the United States universities with fellowships granted by the Rockefeller Foundation, the Guggenheim Foundation, and the U. S. State Department (under the Buenos Aires Convention for the Promotion of Inter-American Cultural Relations). This relationship is expressed in a letter from Dr. Lopes much more eloquently than I could do. "Scientific cooperation with American institutions was one of Wataghin's basic ideas for developing physics in this country. I think this is important since the first group of physicists who got jobs at the Faculties of Science of Rio and São Paulo, after returning from abroad, knew what to do in order to improve conditions for research here and what kind of enthusiasm they had to inject in our Universities in order to establish the right atmosphere for research. Little by little one had to break away from the traditional type of lecturer who gives brilliant lectures but does no research—probably inherited from Spanish and Portuguese Universities. Today the influence of this work is being spread throughout the country and the Universities of Recife, Belo-Horizonte, Curitiba, and Porto-Alegre prepare plans for inviting physicists from abroad to set up Physical Institutes there."

Although many people have aided in the job of collecting material for this paper, I would particularly like to thank Mrs. Christina Buechner, Executive Secretary of the Committee on International Scientific Publication of the National Research Council, who has been of great assistance before, during, and after the trip in planning the itinerary, providing general information on the scientific centers, and in checking the manuscript. The problem of exchange of scientific information and the publishing of scientific results is one of the most crucial facing South American scientists today. This Committee is doing a magnificent job in alleviating this condition by aiding in the exchange of information, the translation of manuscripts, and the direction of scientific material to the appropriate outlets.