Graduate Research Center of the Southwest

Annual Report

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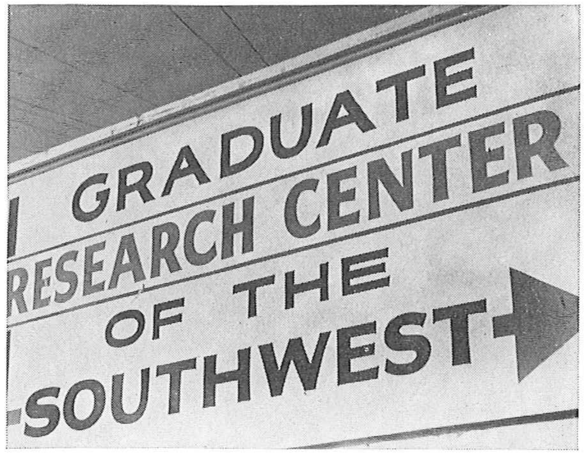
JUNE 30, 1963



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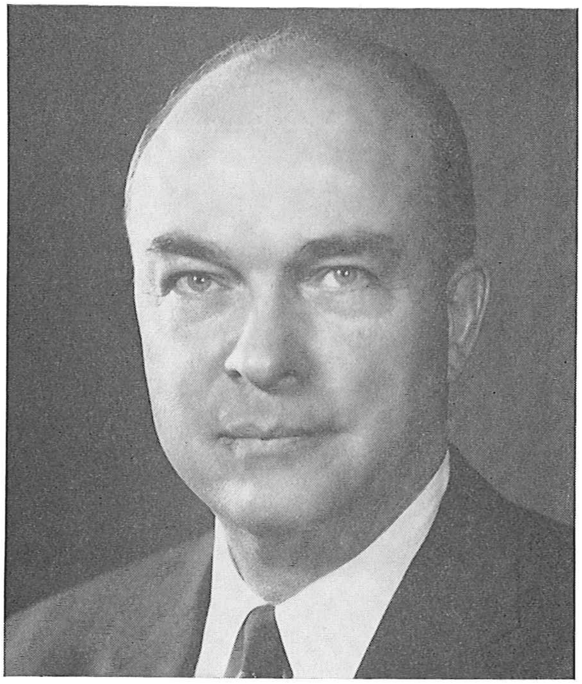
by

THE GRADUATE RESEARCH CENTER OF THE SOUTHWEST

A private, non-profit institution chartered by the State of Texas for purposes of research and advanced graduate education in the public interest.

Foreword



Six years ago, some of us associated with technical industry became acutely conscious of the need to expand the scientific and technological competence of the Southwest. We realized that this problem could be solved only by an aggressive program for enlarging and upgrading advanced education within the region. Some of the universities were already working toward solutions. At that time, we had the seed of an idea for an additional approach which would augment the efforts of the universities and colleges. This germinated in February, 1961, when the Graduate Research Center of the Southwest received its charter. Now this organization, like a young oak, is in a period of rapid and healthy growth.

The Center is conducting fundamental research and teaching at the very boundaries of knowledge in several scientific areas. Other areas of activity will soon be opened.

The Center's impact is being felt in the Southwest, as a force in attracting new science-based industry, in backstopping that already here, and also in catalyzing activities which are enhancing the cultural and academic fabric of our region.

We have been particularly fortunate in obtaining eminent scientists to head these efforts; and they, together with their talented staffs, are attracting other superior men. Upon this group, the success of the entire venture depends. We feel that we have reached the critical mass; the proper scientific climate has been established and the growth from here on will be both steady and sound.

The faculty and staff of the Center now comprise about one hundred. The research goals of this Community of Scholars at present are oriented toward the science of the Earth, the physics of the atmosphere and space, the nature of gravitation, and other intriguing subjects. The research results are being reported in leading journals and at meetings of the world's scientific societies. The value of such a scientific institution, with its diverse talents and facilities, is ever more manifest as a stimulus to the applied research of industry. The growing efforts of Southwestern universities to expand quantity and quality of graduate education, added to the activity of the GRCSW faculty, are exerting a significant influence which will soon be measurable in larger numbers of advanced degrees.

The GRCSW is certainly not the sole answer to the scientific and academic needs of the Southwest. But we are convinced it is an important segment of the answer.

Our growing campus north of Dallas will continue to require the energy and support of the many friends who have assisted us so effectively in this initial phase of growth. We are deeply indebted to all those who participated in our founding fund campaign this past spring; and the counsel and dedication of our friends, both in and out of the academic field, has been invaluable.

I believe you will find the story of the achievements to date both exciting and rewarding. We want you to be fully informed about the Center, and as you read the following pages, we hope you will share our convictions regarding its significance and the support it merits.

Erik Jonsson

Erik Jonsson

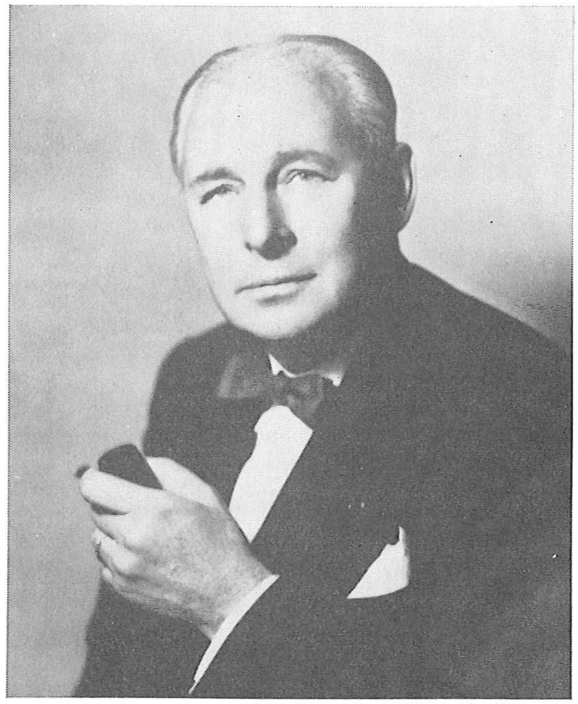
Chairman, Board of Directors
Graduate Research Center of the Southwest

1 - Report of the President

The Precept

To aspire to greatness, any institution must be founded on a great ideal, a precept that significantly recognizes a strong public need. With this clear guidance, the title of greatness can be earned in time, out of the distinction and accomplishment of the institution's works.

The Graduate Research Center of the Southwest is founded on the ideal that man's fundamental resource for the future is the trained, inquiring and creative mind. Through the establishment of a "Community of Scholars", dedicated to the exploration of the most advanced complexities of nature, the progress of the region can be accelerated by greater utilization of the resource of the mind — the only major resource remaining for development to man's benefit.



Toward the Precept

In this first year of operations, the Graduate Research Center of the Southwest could only take the first step on the ladder toward the distinction to which it ultimately aspires.

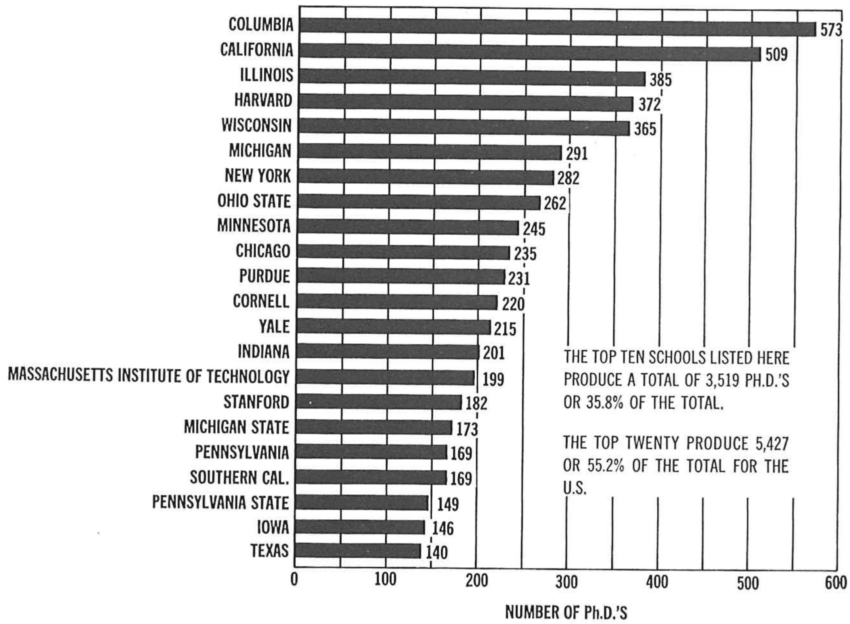
The planning that must precede actual operations has been completed. Large scale research is proceeding in the first laboratory—Earth and Planetary Sciences — with a distinguished faculty, withal in temporary quarters. Measures for the origination of succeeding laboratories are well advanced. Land for the campus has been acquired, a master construction plan has been completed and construction is under way.

Co-operation with the universities of the region has led to the initiation of several new doctoral programs by Southwestern institutions. Joint teaching arrangements have been made in a number of academic areas. Advanced colloquia and symposia of the past year have assisted in improving the intellectual atmosphere. Most gratifying, among the year's developments, has been the enormous and genuine response of the people of the Southwest to the ideal of strengthening the region's inherent intellectual power as a major resource for the future.

Origin of the Ideal

Throughout the ages, leadership of the mind has created innovations that have lifted man from drudgery. Yet, the mere five thousand years of humanity's civilized growth have been chiefly devoted to carving out the basic needs on which a civilization could rise — the means and access to essential products and services, primary roads and transportation, basic communications and housing, the development of natural resources; indeed, the explora-

DOCTORATES CONFERRED 1959-60 (by institutions)



tion and opening of a planet. Therefore, in these first civilized years, man has been preoccupied with obtaining necessities.

Out of this experience have emerged some tested patterns of human relations. Typically, our American scene has emphasized the value of diversity in initiative, management, motivation and thought as a major key to human development.

The twentieth century has seen this first great era of civilization brought to conclusion, with all of the Earth placed within easy reach, for man's utilization.

The last of the useful lands are now open to development. The products of the world can be transported swiftly to all peoples, except as purely political barriers may hinder such exchange. Disease has been conquered to an astounding degree, with the rise of life expectancy since the American Revolution from a mere thirty years to the Biblical three score and ten. Starvation has become unnecessary in a world whose food supply can be expanded tremendously.

Therefore, man's major effort in the future need not be absorbed to eke out an existence. In only four decades, agriculture has been industrialized, now requiring less than seven percent of our population. Manufacture of basic products has increased in efficiency, requiring ever fewer workers to supply the world's needs. Distribution, packaging and preservation have become far more effective.

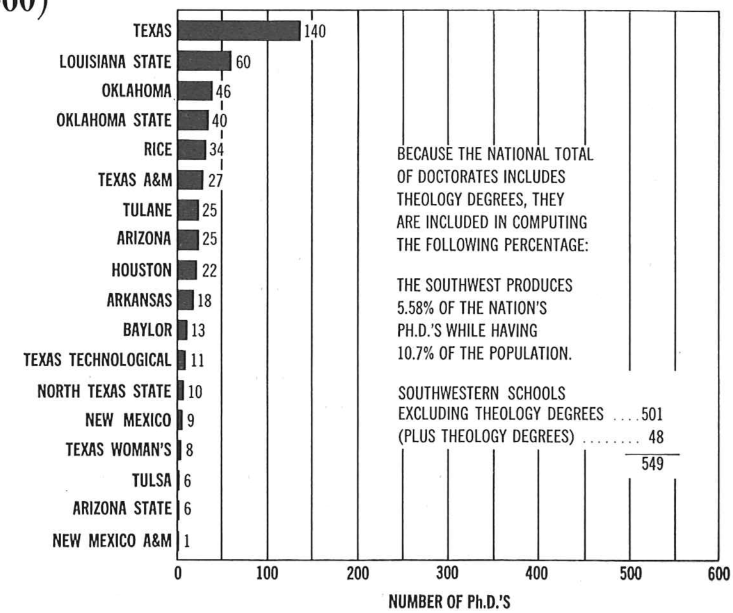
Thus, in an atmosphere of basic sufficiency, and with increasing time to spare, man can turn his attention to new goals. No longer is he concerned primarily with providing the necessities of life; with these readily at hand, he can turn a large portion of his energies to other pursuits.

The New Goals

In an atmosphere of plenty, man not only has the earned right, but also the responsibility to generate new goals that can assure his welfare and happiness in the future. Indeed, it is evident that the old goals are no longer enough. The immense productive power of the individual, derived from today's technology, leaves too many without opportunity. So the future requires a new resource for man's continued development — the resource of the mind.

This implies the need for much greater utilization of the capabilities of the mind. We have long recognized development of the mind as the basic objective of the undergraduate education. In colleges, the individual is provided tools to comprehend the development of human thought and experience over the ages. Through perception of the history of human activity, the student can comprehend his place

DOCTORATES CONFERRED by SOUTHWESTERN UNIVERSITIES (1959-60)



in society, and can avoid the blunders of past experimentation.

But now, when we turn to the mind as the new resource on which the world of the future is to be constructed, mere development of an ability to deal with ordinary situations is not enough.

Over the past century, man has come to recognize the need for formal post graduate education, because education beyond the bachelor's degree has as its objective the development of the mind to deal with novel situations.

In the rough and tumble of opening a planet, such an advanced intellectual goal seemed of minor consequence, because the resources of land and minerals were of necessity the most treasured. But as this task approaches completion — as man turns to the real resources the mind can provide — post graduate education has assumes an altogether new order of importance.

Beginning in the universities of Europe as a spontaneous activity of scholars, graduate education spread to the leading universities of America. Over the past century, some twenty-five or so truly great institutions of advanced learning have emerged. Since 1930, these graduate universities have come to a level of excellence that has equalled, and indeed in some cases surpassed the quality of their precedent institutions abroad.

Today, some 10,000 scholars receive their doctoral degrees each year from American universities. It is important to note that more than one-half of these doctoral awards come from the "Big 20" universities which were well established in pre-World War II years. This is the foundation on which the predominant resource of the future — the mind developed to deal with novel situations — now rests.

Unfortunately, the past quarter century has seen the emergence of no additional great graduate institutions. Large areas of our nation, and whole segments of our population, are unserved by any outstanding graduate universities. At a time when formal graduate education has become essential as the social and economic resource of the future, there is an urgent requirement for the generation of additional excellent graduate institutions.

In the unserved areas of our nation, only about 5 high school graduates of each 1000 achieve the highest graduate degree as contrasted with the nearly 15 per 1000 who, more fortunately, live near a great graduate university.

The powerful influence of the outstanding graduate institutions on the surrounding community is plainly visible, socially, economically, academically, in the regions fortunate enough to have them.

Southwestern Regional Development

The Southwestern region of our country represents one of our most recent frontiers of natural development. Over the past century it has been opened to an incomparable agriculture featuring cotton, cattle, grains, and other agricultural products of major international importance.

It has yielded oil and minerals in profusion. Its rich natural resources have made it a land of opportunity that has attracted population in great numbers. Its development at the very seat of the American "Great West" is the subject of many a song and tale.

During these years, the need for development of the mind, and training it for the tasks at hand, has led to the establishment of more than 100 colleges and universities in the region, primarily for the bachelor's training.

There was little time, so the dates of activation of many of these schools are recent. Only five of them in this partial listing have completed their first century:

Tulane	1834
Southwestern (Georgetown)	1840
Baylor	1845
Austin (Sherman)	1849
Louisiana State	1860
Trinity	1869
Arkansas	1871
Texas A. & M.	1871
Texas Christian	1873
Texas	1884
Arizona	1885
Arizona State	1885
New Mexico	1889
New Mexico State	1889
New Mexico Inst. Mining/Tech.	1889
Oklahoma	1890
Oklahoma State	1890
North Texas State	1890
Louisiana Polytechnic	1894
Southwest Louisiana	1898
Texas Woman's	1903
Rice	1912
Southern Methodist	1915
Texas Tech	1923
Houston	1934
Dallas	1956

The establishment of these universities and colleges was the response to the need for training of leaders, under whom the Southwest could develop in a swift-moving century.

The rapid growth of Southwest industry and education during the past several decades magnifies the problem of grasping the opportunities made available by science. Here, the frontier patterns have been interrupted within a short span of time by technological advances. Abruptly, the Southwest has found a critical need to deal with the novel situations that the future now presents. We have a requirement for much expanded graduate programs that can permit its people to take advantage of the opportunities that are here today.

How can a great people rise to the challenge to increase substantially and quickly the number of highly trained minds? Clearly the only source can be graduate schools of our universities. Which universities should accept the challenge? How many such institutions does the regional community need, and should it support?

How can existing undergraduate institutions rise to graduate stature in a tradition of excellence? How can existing post graduate programs be expanded and made even better? How can the frontiers of the recent past be converted to the new frontiers of the mind in capturing opportunity of the future?

The Necessary Action

These, then, were the questions troubling Southwestern leaders when I first became clearly conscious of this problem. One evening on a flight from Dallas to New York in 1958, Erik Jonsson, Chairman of the Board of Texas Instruments Incorporated of Dallas (and now Chairman of the Board of the Graduate Research Center of the Southwest) opened my eyes to the social and economic revolution into which the world was plunging. He described the picture in terms of the sharp contrasts developing at the recent frontiers, and the problems that our newly developing technological revolution presented at those frontiers.

Here too, I was reminded of my earlier talks with Dean McGee, President of Kerr-McGee Industries, Inc., of Oklahoma City, who likewise was keenly conscious of the quickly changing social and economic patterns.

These were men of immense stature, who through experience and foresight were deeply conscious of the future, and the new resources required to carry us above our present pinnacle of success.

The solution to the problems, in the minds of these men (and as I was soon to find, in the minds of many, many others of the Southwest) hinged on the rapid development of graduate education — the access for every community to the mind developed to deal with novel situations. To them, the whole health and happiness of the future lay in a quick and intelligent response to the new problems of our technological world of the future.

In the ensuing months, I developed a series of studies in the Southwest in an attempt to understand the fundamentals of the situation.[1] The ideals directing these studies grew out of conversations and experience of many leaders who were conscious of the real meaning of events of today.[2]

The proposals of these studies were vigorously debated one historic evening (May 27, 1960) in the rooms of Southern Methodist University, with a group of Southwestern leaders. Present with Mr. Jonsson at this discussion were:

Claude C. Albritton	Robert McCulloch
Harvey Gaylord	Eugene McDermott
Cecil H. Green	Eugene McElvaney
Hemphill Hosford	H. Gardiner Symonds
Stanley Marcus	Willis M. Tate
Lewis W. MacNaughton	C. A. Tatum, Jr.
C. J. McCarthy	

The essence of the proposals was that a regional institution dedicated solely to high scholarship should be founded at Dallas, with the objective and ideal of scholarly research and post doctoral education, to aid in the development of a regional tradition of academic attainment. This institution was to work with universities and their faculties in building graduate opportunities as rapidly as possible. It was to work with industry as a source and storehouse of fundamental thought out of which innovation would be encouraged.

The institution would devote itself entirely to fundamental research and advanced teaching and would not be in competition with the universities in their pre-doctoral work. It would be organized as a university with the highest standards for faculty selection; while qualified to grant degrees to ensure its academic stature, it would not do so in practice, in order to encourage university development within the region.

[1]Subsequently published under the title "Graduate Education in the Southwest", SMU Press, May 1961.
[2]c.f. "Whither Graduate Education?" Physics Today, July, 1963; "The Technological Revolution of Today", Journal of the Franklin Institute, June 1963.

A Community of Scholars

In its initial phases, it would devote its work primarily to the natural and life sciences, although its objectives involved one of the great experiments in social science of modern time. It would be a "Community of Scholars" in the highest sense of the ideal.

The basic theme of the plan was to work from the top down. Only when real scholarship at the advanced level was broadly developed in the Southwest, could the full potential of the universities — and indeed the whole region — be released. Such an institution could earn and enjoy an international reputation. The experience of institutions such as the Brookhaven National Laboratory had shown that their direct influence can extend for many hundreds of miles throughout the region.

In dedicating its efforts to catalyzing the "development of the mind to cope with novel situations," with research as an essential part of this process, the planning group recognized that the Center could initiate various aspects of applied research; but, with unanimity, the group felt that research directed toward particular products and services is properly a function of industry. However, to accomplish well this task of technological innovation, industry must have intimate access to the whole substratum of an advancing science.

Thus, the task of the Center, and of the universities of the region was, and is, to create a sense of intimate contact between science and industry, out of the broad scientific foundations that advanced research and education can provide. Through basic intellectual development of the environment, the Center should aspire to the creation of an atmosphere of intellectual advancement within which every element of the region can flourish.

The May evening meeting ended with the clear determination to undertake the founding of such an institution. In the following December, I joined with the group to bring that institution to life.

Founding the Center

The Graduate Research Center of the Southwest and its research arm, the Southwest Center for Advanced Studies, came into being on paper February 14, 1961, when it received its Charter from the State of Texas as a non-profit educational institution with degree-granting authority — an authority which it does not plan to use.

Activation of the institution was made possible by the generous initial guarantees of

Erik and Margaret Jonsson
Cecil and Ida Green
Eugene and Margaret McDermott

who together ensured its beginnings.

The year 1961 and early months of 1962 were devoted to planning and to the wide variety of details that underlie the founding of a major intellectual enterprise. Almost immediately I was joined by Prof. Ted Brannen, Dr. Ralph Stohl and Mr. Frank Seay who, together with many members of the community whose names appear on the Board of Directors and the Advisory Council, formed the planning staff. Professor Brannen explored with the universities possibilities for co-operative activities; Dr. Stohl undertook administrative and financial planning; Mr. Seay acted as planning co-ordinator and with Dr. Stohl worked on the assembly of the campus and master-planning co-ordination.

Late in 1961, Prof. Lauriston C. Marshall joined us to establish the Office of Scientific Personnel and aid in development of the faculty. Throughout this initial period of planning and development we had the unstinting help of men throughout the Southwest. The business leadership of the region was enthusiastic in its assistance.

In particular, the Graduate Research Center of the Southwest owes a debt of gratitude to SMU that can never be repaid. President Tate and his administration generously opened the administrative offices of SMU to house us in our initial effort. Later we took more spacious quarters in the Science Information Center, where we now occupy 20,000 square feet.

Early Milestones

Research operations of the Southwest Center for Advanced Studies began properly when Prof. Francis S. Johnson and the first of his colleagues arrived at the Center in April, 1962, to found the first research division—the Division of Atmospheric and Space Sciences of the Laboratory of Earth and Planetary Sciences.

Professor Jonsson was followed in September, 1962, by Prof. Anton Hales, Head of the Division of Geosciences, and in March, 1963, by Prof. Ivor Robinson, Head of the Division of Mathematics and Mathematical Physics. With the subsequent development of a Division of Hydro-Meteorology we hope to complete the organization of the Laboratory of Earth and Planetary Sciences in the coming year.

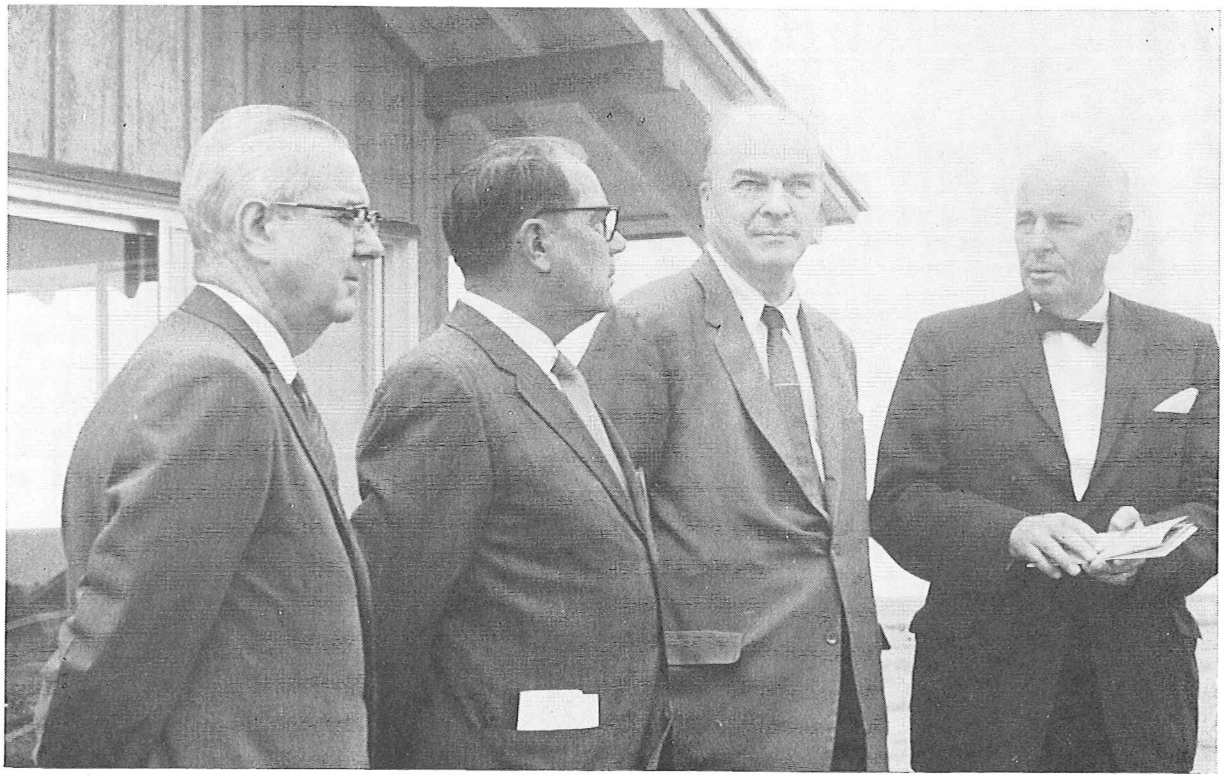
The faculty of this first laboratory has grown rapidly and their names appear later in this report.

A major development was the initial drive for funds for the new institution held in Dallas County during February-March, 1963. The Dallas Founding Fund Campaign, headed by C. A. Tatum, Jr., and Stanley Marcus as co-chairmen, progressed swiftly toward its five-year goal of $5,000,000. Longer range financial plans for the institution are detailed later in this report.

A second noteworthy development was the completion of the Dallas Magnetic Observatory and its dedication on July 11, 1963. Through a novel arrangement of the Center with the Federal Government and private industry, a powerful research tool is made available in the Southwest.

The Observatory and its laboratory were built by Texas Instruments Incorporated and dedicated to the Center. The apparatus and its operation are supplied by the U. S. Coast and Geodetic Survey under an agreement formally executed between Admiral H. Arnold Karo and the Center. The management responsibility for the Observatory rests with the Center. Outputs of recordings and the fine, carefully designed magnetic laboratory itself are available to government, industry, and the universities, and a powerful series of researches has begun. In addition, the geomagnetic records supplement the data of the three other geomagnetic observatories of the government.

The pattern of mutual co-operation developed by Dr. Christopher E. Barthel, Jr., Chief Scientist, Coast and Geodetic Survey; Sr. Vice President Walter F. Joyce, Texas Instruments Incorporated, and Mr. Frank Seay of the Center represents great cost savings to government, industry and education, and has established a precedent for similar developments.



Dedication of Dallas Magnetic Observatory, July 11, 1963. At left, Dr. Christopher E. Barthel, Jr., chief scientist, U. S. Coast and Geodetic Survey; Mr. Walter F. Joyce, senior vice president, Texas Instruments Incorporated; Mr. Erik Jonsson, chairman of the board, Graduate Research Center of the Southwest, and Dr. Lloyd Berkner, president, Graduate Research Center of the Southwest.

The Center's Organization

As the Center has moved into the phase of active operations it has developed a more formal organization.

The governing body of the Graduate Research Center of the Southwest is the Board of Directors, which under the bylaws requires representation by public members and by members drawn from academic institutions including the GRCSW itself. It is supported by a larger Advisory Council, the members of which are selected principally from industry and commerce.

A small administrative group headed by the President is responsible for the management of the Center.

The academic policy of the Center is developed by the Academic Committee consisting of representation drawn from the faculty members on tenure.

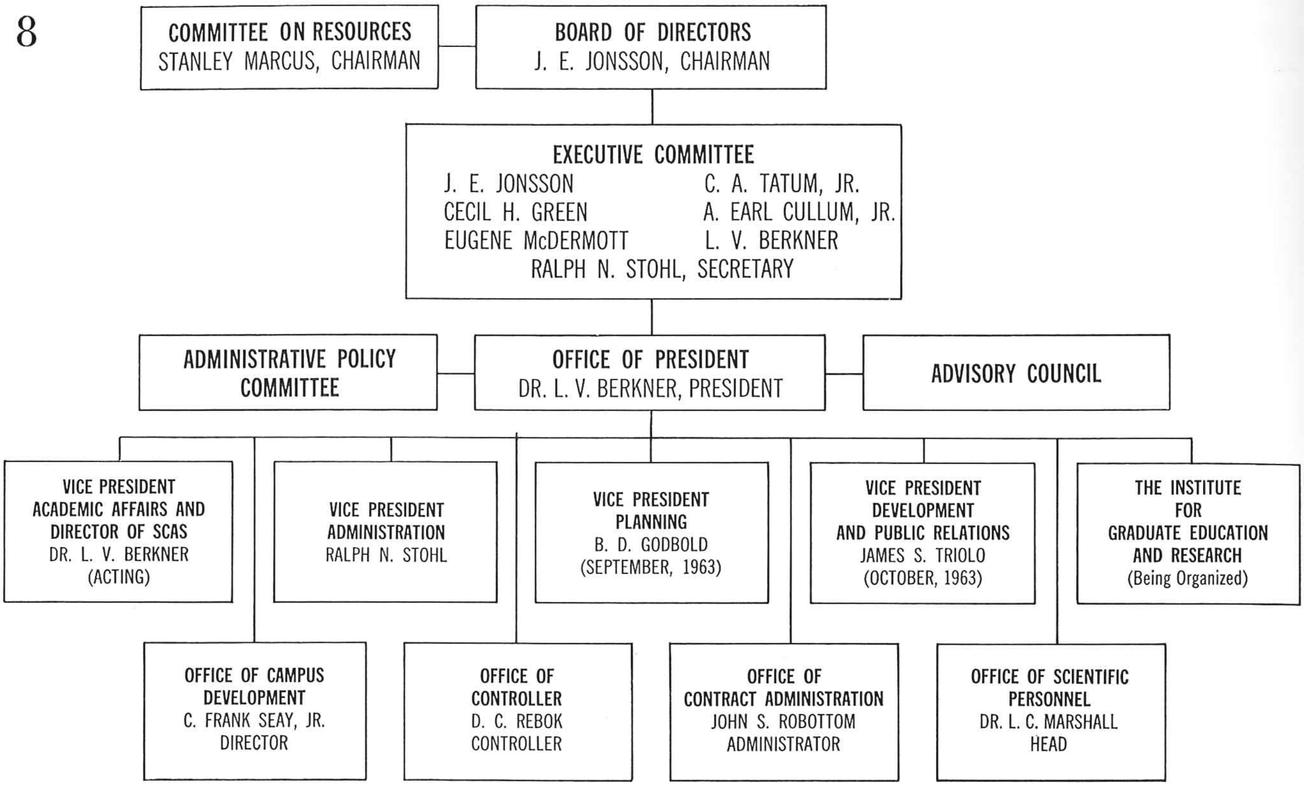
The Administrative Policy Committee acts as a policy council on all questions not directly involving the institution's academic development.

All major policy problems and senior appointments are considered by the Executive Committee, to which the Board has delegated authority to act. The Executive Committee meets at least monthly.

All internal academic activities are organized under the Southwest Center for Advanced Studies. The major centers of activity, designed as Laboratories, are interdisciplinary in character and focused on broad areas of scientific enthusiasm.

They include:

1. Laboratory of Earth and Planetary Sciences (activated April, 1962)
2. Laboratory of Computer Sciences (to be activated, Late 1963)



Organization Chart, Graduate Research Center of the Southwest

3. Laboratory of Molecular Sciences (planned for activation, 1964)
4. Laboratory of Materials Sciences (planned for activation, 1965)
5. Laboratory of Electronics Sciences (planned for partial activation, 1964)

The Southwest Center for Advanced Studies has and will have on its campus a strong but small permanent faculty. It also will have a rotating staff comprising three categories: faculty members and scientists on leave from universities and other institutions for periods ranging from a few months to two or three years; graduate students from other universities working on their doctoral theses; and young scientists (most of whom will have just received their Ph.D.'s) not affiliated with other institutions who, during a few years spent at the Center, will broaden their knowledge and skills before moving on to more advanced academic responsibilities.

To ensure the high academic qualification of each member of the faculty, qualifications of proposed appointees are reviewed by a sub-committee of the Academic Committee, appointed in each case with special reference to the qualifications involved.

Full time senior faculty members, with unique responsibilities for research and graduate development, together with other faculty in the professor and associate professor category, are eligible for tenure appointments. The selection for appointments to tenure positions is made only after careful and extensive consideration. Tenure appointments must be confirmed by the Board of Directors of the Graduate Research Center of the Southwest.

The objective of the Southwest Center for Advanced Studies is creative scientific research and advanced educational opportunity — scholarship in the highest sense; thus, the management of its affairs is carried out in an atmosphere of full investigational freedom, and is designed to encourage advanced and creative thinking. Coupled with the privileges of tenure are staff responsibilities to maintain skills at the limits of knowledge, and to assume initiative in generating opportunities for advanced studies with their colleagues.

Within the Southwest Center for Advanced Studies the five laboratories will have comprehensive responsibility in their fields of research. Each laboratory head is responsible to the Director of the Southwest Center for Advanced Studies for the determination of the broad areas of research to be pursued, for the determination of the personnel required and their nomination, and for the effectiveness of the research within his area of responsibility, including the accomplishments of the goals which have been set.

In activating the Laboratory of Earth and Planetary Sciences, particular attention has been given to relief of faculty from administrative detail. The appointment of a scientifically trained and experienced Executive Officer, Mr. Ross Peavey, has established a pattern that minimizes the administrative problems of the faculty. Consequently, all individuals holding academic rank in the Center can participate actively in research, without an undue burden of supplementary administrative tasks.

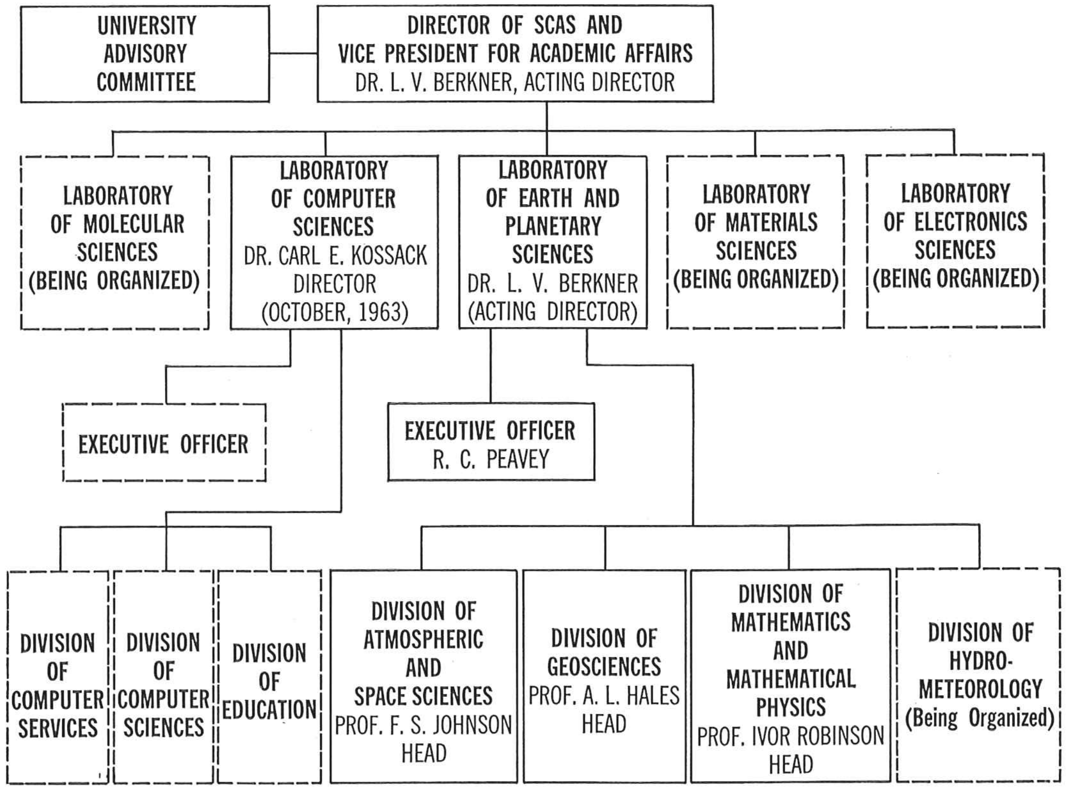
As the scope of university co-operation is extended, the Center is planning the establishment of The Institute for Graduate Education and Research, to provide formal means for such co-operation. Work in this field continued directly under the Graduate Research Center of the Southwest during the fiscal year 1963.

In particular, we believe the key to development of great graduate schools in the future lies in conscious planning of university development. The very failure of new graduate institutions to emerge during the past two decades is clearly indicative of a major change in the fundamental atmosphere in which such development can occur. Therefore, the Center is devoting major study to this problem, with the hope of assisting in such development in the future, through elaboration of suitable planning measures.

Campus Development

The Center is now rising on an extensive tract on the north boundary of Dallas County, adjoining the suburban cities of Richardson and Plano. There is ready and quick highway access to all universities of the Dallas-Fort Worth-Denton metropolitan complex, to the two major airports, and to the excellent private airport at nearby Addison.

The campus proper is an area of about 340 acres on gently sloping high land, with a fine view of the



Organization Chart, Southwest Center for Advanced Studies

Dallas skyline about 18 miles to the south. The core area is surrounded by an additional 1060 acres belonging to the Center, and a contiguous 700 acres of the Texas Research Foundation. The circumferential lands of the Center will be used for encouragement of industrial research in close proximity to the basic research facilities of the Center, with design of such facilities in consonance with the general academic atmosphere of the Center.

The Master Plan, worked out by Messrs. Ford, Zisman and Associates, visualizes a closely knit group of buildings, coupled to give an air of intimacy, and separated only by small gardens. Upon entering the complex, undercover access to any laboratory is possible, and the arrangement is designed to convey the impression of a single extended unit. The design encourages frequent meeting of faculty of all laboratories in the normal courses of their work.

The main road is a perimeter, with screened parking lots accessible to each building. Service entrances to the buildings are arranged from the perimeter road, through tunnels and below-grade ramps. A special area to the north of the central complex provides for temporary special experimental structures.

Research Programs

The active research program, now in progress in the Laboratory of Earth and Planetary Sciences, typifies the types of educational activity visualized for the Center as it develops. In this Laboratory, the objective is to develop inquiries into all aspects of Earth and Planetary environments, from studies of the interiors of the planets to the influences exercised by the Sun and the interplanetary medium. The work is developed around centers of scientific enthusiasm, with individual curiosity and inquiry given full play. Particular emphasis is given to interposition of interdisciplinary skills, involving all areas of science, to encourage the broadest synthesis of ideas in the exploration of new scientific areas.

Each member of the faculty is encouraged to develop several lines of research inquiry simultaneously, to avoid the stultification that may develop out of pressing an inquiry in too narrow an atmosphere of specialization.

In their content, the researches on the Earth, the Planets and the Solar System stem from the growing interest in the history and character of the environment out of which life has originated and developed. This is the environment that provides the physical resources on which man and indeed all terrestrial life depends. Not only does man have an intense interest in the details of the origin of life on Earth, but also in the natural origin and character of the resources and phenomena on which future civilized development must rest.

Recent, expanding accessibility to space, the Moon and the planets through space vehicles provides powerful new means of elucidating the whole environment in which man has risen.

The researches of the Laboratory of Earth and Planetary Sciences include:

1. Exploration of the Earth's crust and interior through studies of seismic waves, geomagnetism, and the gravitational field.

2. The history of development of the Earth and its atmosphere, through studies of geochronology of the radioactivity of the crust, paleomagnetism of the rocks, and photochemistry of its atmosphere, as well as micropaleontology.

3. Geochemical development studies of the rocks under conditions of high pressure and temperature.

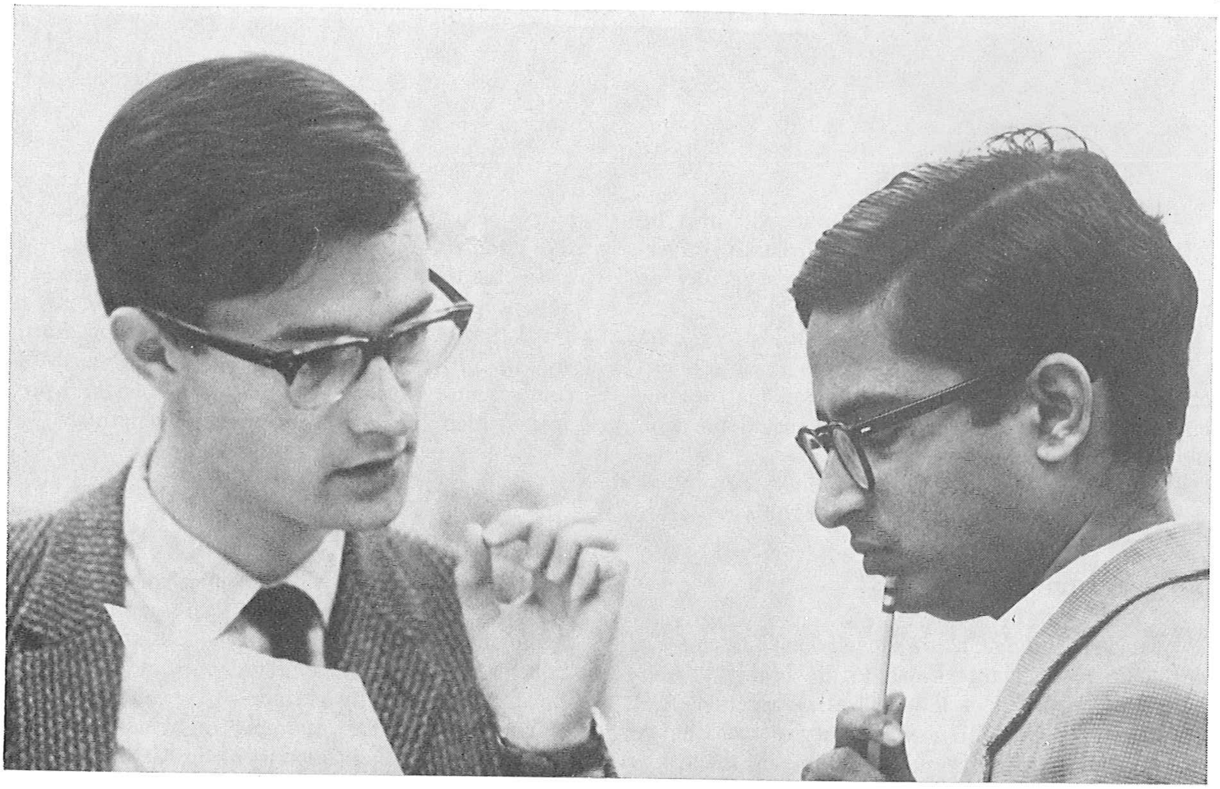
4. Physics of the atmosphere, and of the ionosphere and the magnetosphere out to the boundaries of the atmosphere and the geomagnetic field.

5. Interplanetary space, and the winds and shock waves that traverse it.

6. The Moon and the planets, with the special evidence that they can provide concerning the formation and differentiation of the Solar System.

7. Cosmic rays, as sensitive indicators of the character of the extra-terrestrial space that they traverse.

Through the development of a complete knowledge of his environment in the universe, its history and its character, man will grow in stature and in the clearer conception of his civilized goals. Out of this knowledge he can more readily adjust to that environment, to the storms, the earthquakes, and the cataclysms that are inherent in it; to its control and its response to his needs for food and resources as his population expands; and to its use for his welfare and protection in a nuclear age.



Among early appointees as Research Associates, for post-doctoral study, were Dr. T. N. L. Patterson, left, of Queen's University, Belfast, and Dr. S. S. Degaonkar, of the Physical Research Laboratory, Ahmedabad, India and Gujarat University. Dr. Patterson has since been named an assistant professor of the Southwest Center for Advanced Studies.

Instructional Programs

The advanced student plays a major role in the center. In a sense everyone is a student, although some are more experienced and skilled than others.

Already substantial numbers of post-doctoral students have joined in the work of the Center and this number is increasing steadily.

The principal instructional activity lies, of course, in the faculty counseling of students as they approach unfamiliar situations. Out of this post-doctoral association, the emergence of great faculty and research leaders is certain.

In association with the universities of the region, a small but increasing number of pre-doctoral students are doing and will do their dissertations at the Center. Faculty counselors are appointed from the Center as adjunct faculty of the university at which the student is matriculated, and as members of his examining committee. In this way, graduate opportunity of region is enormously broadened.

The first formal graduate program, a doctoral program in geophysics, has been developed at Southern Methodist University through a joint agreement with the Center. Under this arrangement, the faculties of the two institutions are joined to form one of the leading geophysics faculties of the world.

A somewhat less formal arrangement with the University of Texas has stimulated an active doctoral program in the field of relativity studies.

Other such programs, through joint affiliation of faculties, are being formed in special fields with Rice, North Texas State University, and others. Joint research in oceanography with the Agricultural and Mechanical University of Texas is being planned.

During the past year a series of distinguished colloquia on a variety of subjects was conducted at the Center. A special advanced weekly seminar on outer atmospheric and space physics was developed by the faculty of the Atmospheric and Space Sciences Division. The notes of this seminar have been formally organized as perhaps the most up-to-date assembly of knowledge in this field.

Similar seminars will be conducted by the division's faculty at the National Aeronautics and Space Administration's Manned Spacecraft Center in Houston.

A formal, graduate college course will also be offered in the fall of 1963 at Texas Christian University in Fort Worth, with the Center's faculty as teachers.

Throughout the educational effort the stress is on synthesis of scientific knowledge into critical theoretical comprehension of the phenomena of our environment. Experiment is the means to the supply of knowledge to this end.

Detailed content of the research programs is described in the following chapters of this report.

The Future

In this special age, as we move from the primitive development of Planet Earth to the highly technological employment of the natural resources that it provides, our education must keep pace. Energy driving the machine is quickly replacing the drudgery of manual labor. Man now turns to that most marvelous of all works — the human mind — for the resource from which the future will rise.

In this time of transition, the ultimate success of any people lies in their vision and their goals toward that new future. The very recognition, by the leaders of a great region of our nation, of the fundamental character of that future is the source from which the Center draws its strength.

Acknowledgement and Dedication

Any new institution owes a debt of gratitude to all those leaders who so wholeheartedly have given of their time and services in its founding. I could name literally hundreds of men and women of the Southwest who have rendered outstanding services during the founding period.

To them, in fullest appreciation of their unswerving loyalty and their support of the Center's precept and objectives, this report is dedicated.

Lloyd V. Berkner

President
August 7, 1963

2 - Report of the Laboratory of Earth and Planetary Sciences

Southwest Center for Advanced Studies

Program of the Atmospheric and Space Sciences Division

A. General Objective

The objective of the Atmospheric and Space Sciences Division is to develop as completely as possible an understanding of planetary atmospheres and interplanetary space (which includes the outer atmosphere of the sun). It is convenient in describing the over-all program to subdivide it into a number of areas. This compartmenting is generally arbitrary, and the areas are frequently so highly interrelated that a given scientist's work may appropriately be included in several of the areas. The areas, although they are described separately, cannot be studied independently of one another; it is felt that the strength of the over-all program will depend to a considerable degree on its breadth, or upon the support that the various areas derive from one another.

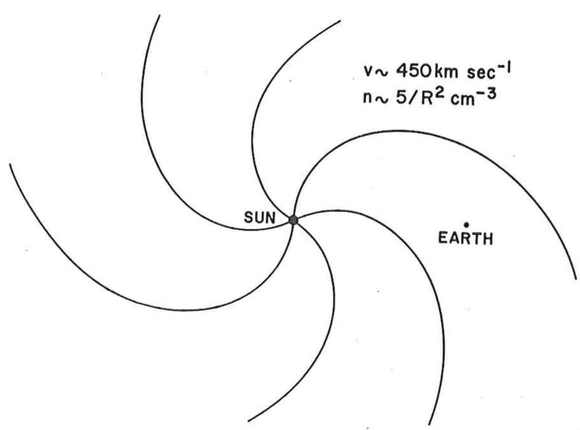
B. Specific Research Projects

1. HISTORY OF THE EARTH'S ATMOSPHERE

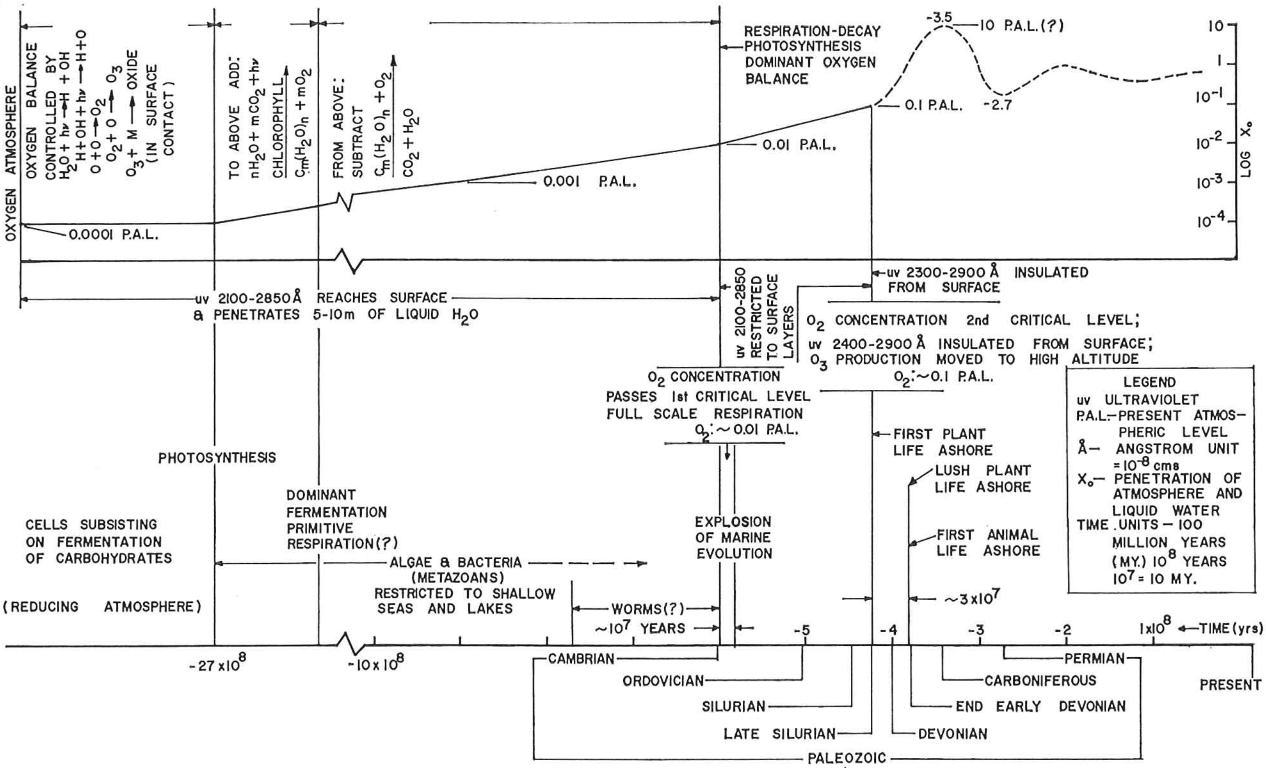
It is important in the atmospheric program to consider the reasons why atmospheres exist, and their stages of evolution. An understanding of the history of the Earth's atmosphere will improve capability of predicting the atmospheres to be expected on other planets; it will also assist in developing accurate pictures of those atmospheres from fragmentary data. Consequently, the evolution of the Earth's atmosphere is being studied, under a grant from the National Science Foundation, using mainly geologic evidence combined with a knowledge of biological evolution, properties of atmospheric gases, and their chemical evolution under the influence of solar radiation.

From current studies conducted by Drs. Lloyd V. Berkner and Lauriston C. Marshall, it appears that it will be possible to establish the time when enough oxygen was released into the atmosphere from biological processes in the seas to permit the formation of an ozone layer of sufficient opacity in the ultraviolet to attenuate the germicidal ultraviolet radiation from the sun. At this time, life became possible on land, and nearly all varieties of aquatic life developed land-based species.

Mathematical models of the relative proportions of atmospheric constituents during successive geologic ages and their variation with time are being formulated, with special reference to the genesis of



The average orientation to be expected for the solar magnetic field as the result of combined effects of the solar wind and the Sun's rotation.



Tentative model, origins of oxygen within the Earth's atmosphere.

atmospheric oxygen, the disappearance of primitive gases, and the modification of carbon dioxide content in the atmosphere.

2. ATMOSPHERIC STRUCTURE

Planetary atmospheres decrease (roughly) exponentially with distance above the surface of the planet, and hence possess no distinct or definite outer limit. Above some level, the atmosphere is so rarefied that collisions between atmospheric particles can generally be neglected; this region is known as the exosphere. In the case of the Earth, and probably also in the case of some of the other planets, there is an extension of the atmosphere to extreme levels due to atomic hydrogen in the atmosphere; this extended and exceedingly rarefied extension to the atmosphere is known as a geo-corona (or telluric hydrogen corona).

To give a reasonably comprehensive picture of a planetary atmosphere, even in an average sense, vertical distributions of composition, temperature, and density (or pressure) must be specified. Even in the case of the Earth's atmosphere, it is not possible at present to do this with much precision, although the general picture of the Earth's atmosphere is rather well developed. The most abundantly available upper atmospheric data are obtained from the measured rates of orbital decay of artificial Earth satellites — these are atmospheric density data averaged over considerable areas of space and time.

It has not been possible in the past to obtain any direct measurements of atmospheric temperature at high altitudes, and atmospheric composition has proved difficult to measure. Consequently, most of our knowledge of upper atmospheric structure is the result of the application of theory to the problem, using the vertical distribution of atmospheric density as the principal input data. Quite comprehensive pictures have been developed in this way, although the exact values of many of the parameters describing the physical state of the upper atmosphere are in considerable doubt. It is in the reduction of this doubt that experimental measures, particularly of temperature and of composition, will be of great importance.

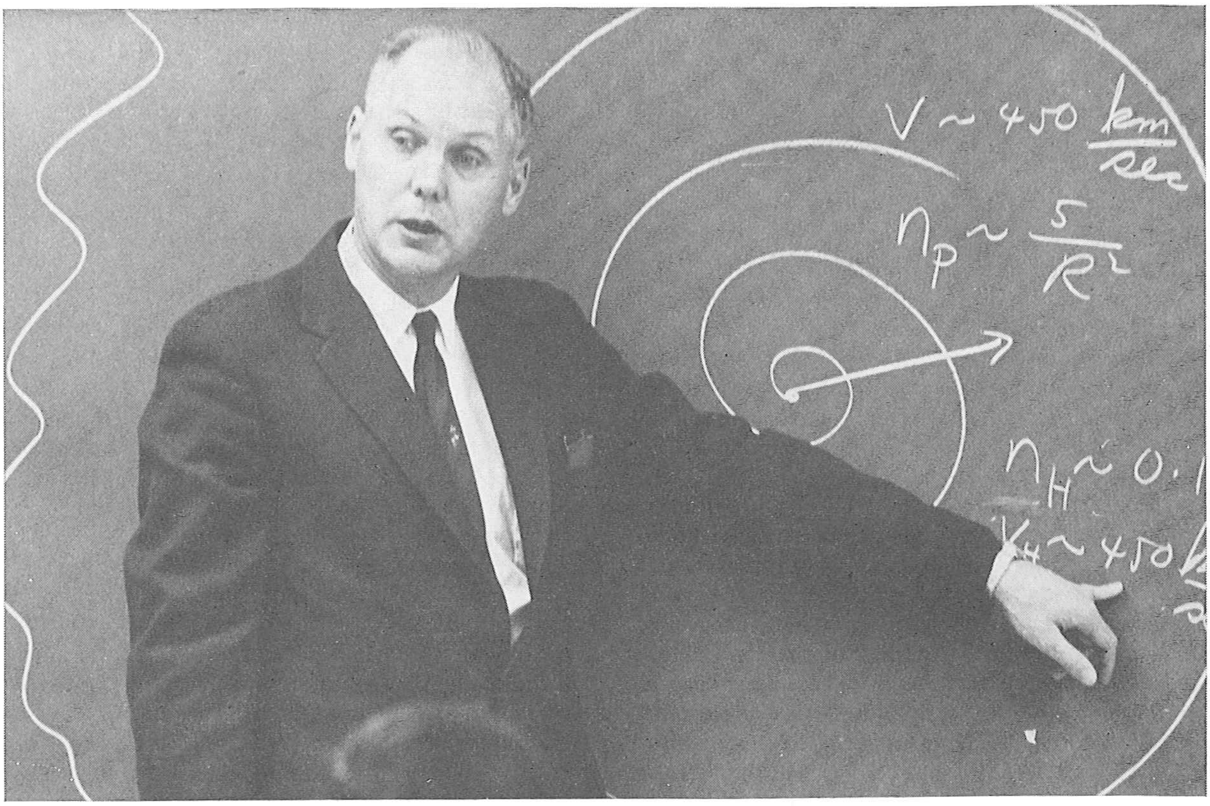
A research program, supported by the National Aeronautics and Space Administration, has been undertaken in the Division to develop the fullest possible understanding of the available data relating to atmospheric structure. The principal investigator is Prof. Francis S. Johnson. Initially, the study includes only the understanding of the vertical structure of the atmosphere in an average sense, but it must increasingly take into account the effects of horizontal and vertical motion in the upper atmosphere and of variations that occur with latitude, time of day, solar activity, phase of the sunspot cycle, etc. Profs. William B. Hanson and Thomas N. L. Patterson have developed the picture of the diurnal flow of hydrogen in the exosphere. A measurement program is being planned to augment the existing data and the data continuously becoming available from other laboratories; two types of mass spectrometers are being designed to make direct determinations of atmospheric composition.

Although the initial measurements are planned for experiments with high-altitude rockets, similar measurements are contemplated for flight in a satellite whose aspect is controlled relative to the flight direction. Mr. Thomas W. Flowerday is directing the development of this experimental equipment.

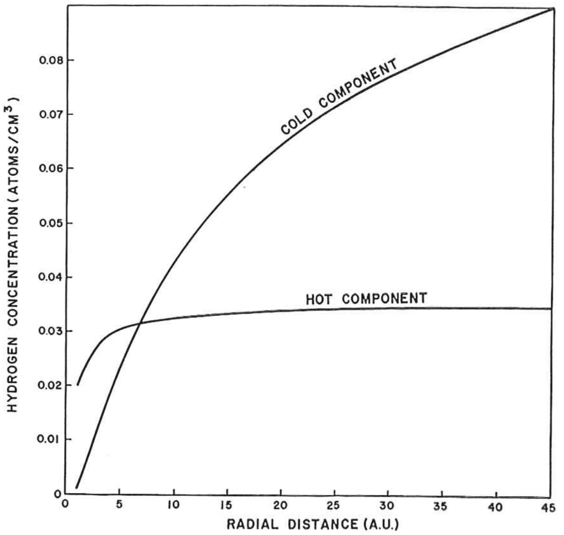
3. IONOSPHERIC STRUCTURE

The ionized gas which constitutes the ionosphere is of very low concentration compared to the neutral atmosphere, although in the geocorona the ionized and neutral constituents may be about equally concentrated. The ionosphere is divided into regions: D (50-85 km), E (85-140 km), F1 (140-200 km), and F2 (above 200 km). The zone of maximum ion concentration, known as the F2 peak, occurs at about 350-km altitude. The ions near the F2 peak consist mainly of atomic oxygen. From about 1000 to 3000 km, the predominant ion is helium; and above 3000 km, atomic hydrogen (these altitudes vary considerably through a sunspot cycle).

Ionospheric structure studies in the Division are rather closely related to the studies of the structure of the neutral atmosphere. The understanding of the ionosphere is really the problem of under-



Prof. Francis S. Johnson, Head, Atmospheric and Space Sciences Division



The distribution of neutral atomic hydrogen in the solar system. Curves indicate the concentrations required to explain observed scattering of solar Lyman-alpha radiation by hydrogen entering the solar system with velocities of either 500 km/sec or 10 km/sec; either curve by itself indicates enough hydrogen to explain the observations. Variations in concentration with distance result from photoionization and charge exchange with the solar wind.

standing atmospheric chemistry (including photochemistry) and diffusion; and this cannot be done without a good description of the neutral atmosphere, which provides the predominant constituents for the chemical system. Professors Hanson and Patterson have determined the conditions governing the diffusion of hydrogen and helium ions in the exosphere; their studies have been very useful in the interpretation of rocket and satellite data obtained by NASA.

The experimental portion of this program is closely allied to the experimental program for atmospheric structure and ultimately both rocket and satellite measurements are planned. Ion traps and mass spectrometers will be used in both programs, although there are differences in the method of operation or in the extraction of data. In the case of determining the ion composition with a mass spectrometer, no ionizing source is required, as the ions are already present; when making measurements of the neutral atmosphere, an ionizing source is required.

In the case of the ion trap, it can in its simplest form be used to measure the concentration of ions; if more attention is given to the nature of the ion-current modulation by grid voltage, some information can be obtained on ion species. Further, if a single ion predominates, the ion temperature can be measured. (Theoretical considerations indicate that the ion temperature must be very nearly the same as the neutral particle temperature, although the electron temperature may be much higher; thus a measurement of ion temperature would be very valuable from the standpoint of atmospheric structure.) A detector for electrons with sufficient energy to ionize atmospheric gas is being developed for use in satellites.

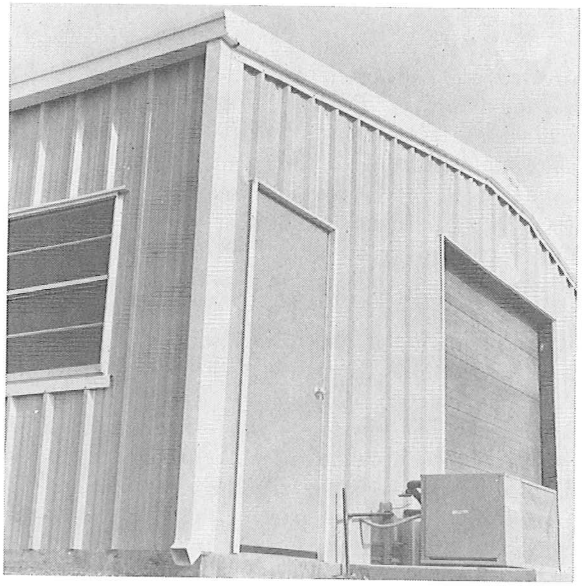
This program is supported by the National Aeronautics and Space Administration.

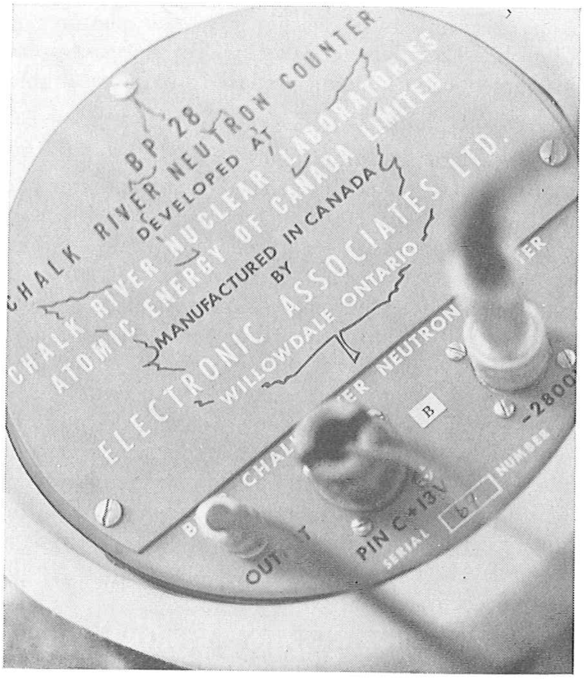
4. GEOMAGNETISM

The Earth's magnetic field originates mainly within the Earth. However, there is a small external component that varies irregularly with time over a range of frequencies from a few cycles per second down to about 10^{-6} cps. (Higher frequency variations also occur, but these are generally considered to be a part of the radio-noise spectrum.)

This divisional program in geomagnetism includes studies of the time variations in the geomagnetic field, the extent of the magnetic field in space, and the deformation of geomagnetic and interplanetary fields by charged particles. This work is closely related to high-energy penetrating particle radiation studies, much of which must be considered as part of the geomagnetism work (for example, the Van Allen radiation creates a ring current which distorts the geomagnetic field in space).

Other aspects of upper atmospheric and space sciences are also intimately involved (for example, the lifetime of high-energy or moderate-energy charged particles trapped in the magnetic field depends upon the concentration of atmospheric particles which through collisions can remove the trapped particles from their stable orbits). Further, the presence of charged particles in the magnetic field strongly affects the propagation of magnetic variations; in other words, extremely low frequency electromagnetic waves (generally, below approximately 100 cps) propagate above the ionosphere only as hydromagnetic (i.e., magneto-hydrodynamic) waves.





Super Neutron Monitor station building on SCAS campus (above). Neutron counter to be installed at station (below).

Under support provided by the National Aeronautics and Space Administration, Prof. Jules A. Fejer has studied the problem of the flow of solar plasma past the outer boundary of the earth's magnetic field, considering both the stability criteria involved and the transmission of hydromagnetic waves across the interface. He has also shown how convection in the magnetosphere can be expected to occur as a result of the deformation of the geomagnetic field by the solar wind. Dr. James E. Midgley is making additional studies of similar problems, with a view to improving the understanding of the deformation of the geomagnetic field by the solar wind and by geomagnetic storms.

The experimental portion of this program will be carried out at the Dallas Magnetic Observatory, on the Center's campus, where the U. S. Coast and Geodetic Survey has a standard geomagnetic observatory (Refer to Magnetic Facility Section). It will consist of observations over a broad frequency range, roughly from 100 to 0.01 cps: these observations will complement those of lower frequency (to zero frequency, or d-c) made by the Coast and Geodetic Survey. Spectral analysis of magnetic records will initially be made in the 0.1 to 10 cps range. A metastable helium magnetometer will probably be used, although an iron core induction coil is also planned. A co-operative program with other interested scientists in the area has been developed and will be initiated during the next year. Later on, there is the likelihood that magnetic measurements above the ionosphere, in rockets or satellites, will be a part of the program.

5. ENERGETIC PARTICLES

There are several interesting types of energetic particles in space. Galactic cosmic radiation particles have the highest energy and are the most penetrating. Next are the solar flare cosmic radiation particles (ejected during some solar flares). When one of these solar flare events occurs, the general level of penetrating radiation in interplanetary space goes up very markedly, although generally for only a few days. Finally, there are the high energy particles (Van Allen radiation) which are trapped in the Earth's magnetic field in such a way as to form a belt around the Earth.

Cosmic radiation time variations, which are associated with variations in the outstreaming of material from the sun, are being studied in an attempt to discover the mechanism responsible for the variation. In space far from the solar system, it is inconceivable that time variations of the sort observed on Earth occur; hence there must be a solar system mechanism for modulation of the cosmic radiation.

Solar flare cosmic radiation events were discovered and identified only in recent years, near the maximum of the last sun-spot cycle. Too few critical observations were made to provide for a good understanding of the events, and more observations will not be forthcoming for several years (near the maximum of the next sunspot cycle), as the events tend to occur mainly near the maximum of the sunspot cycle. Owing to the importance of these events in connection with manned space flight, it is important that the most discriminating studies and observations be made. With support from the National Science Foundation, Prof. Kenneth G. McCracken has developed super neutron monitors which will be installed in southern Canada and in Dallas during the early fall; these installations will represent a significant part of the Center's contribution to the program for the International Years of the Quiet Sun, 1964-1965. Professor McCracken is also concluding development of equipment for balloon observations of cosmic rays this summer at Churchill, Canada, and Palestine, Texas. Space probe instrumentation is being prepared for future flights.

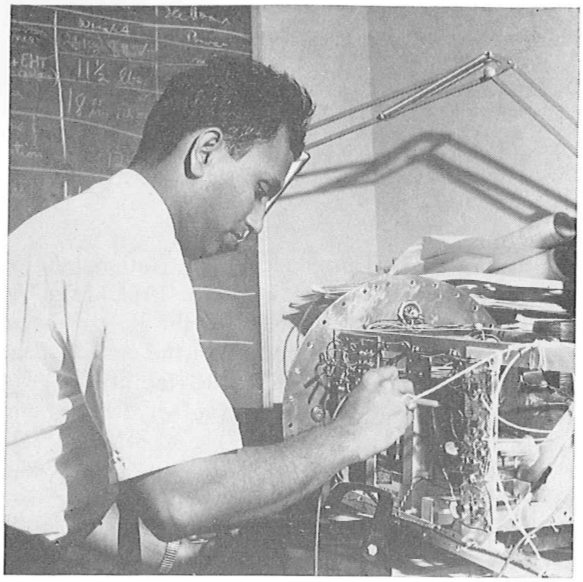
6. ATMOSPHERIC DYNAMICS

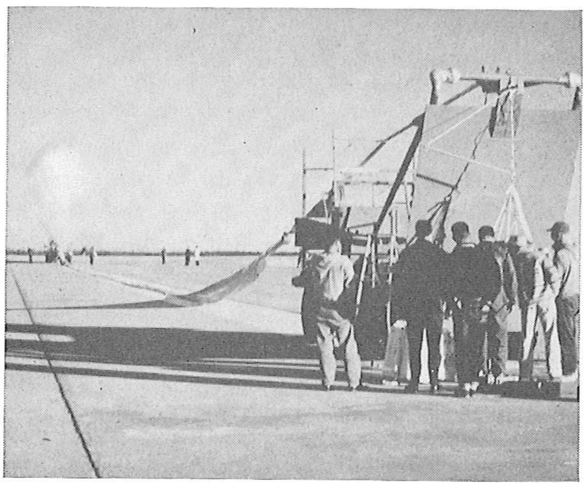
Planetary atmospheres exhibit complicated motions that result in general from the unequal heating of the planetary surface, coupled with planetary rotation. The organized large-scale motions of the lower atmosphere receive careful study in the science of meteorology. However, such motions must extend on up to very high levels in the atmosphere, certainly in a seasonal sense, and probably even in connection with the storm centers.

Atmospheric motions or dynamics are being studied by Professor Johnson under support from the U.S. Weather Bureau. Particular emphasis is being placed on the highest atmospheric levels; this involves a thorough understanding of the motions at lower levels, where most of the energy input to the system occurs.

7. INTERPLANETARY ASTROPHYSICS

A program of theoretical studies supported by the National Aeronautics and Space Administration has been established to determine conditions in interplanetary space. Professors Patterson, Johnson, and Hanson have calculated the neutral hydrogen distribution throughout the solar system.





Cosmic ray instrumentation developed for balloon observations (top). Antenna installation for ground station telemetry (center). Balloon preparation for typical high-altitude instrument flight (bottom).

C. Publications

Degoankar, S. S., "The geomagnetic field variation with solar activity at Tucson", Submitted to J. Geophys. Res. (July, 1963).

Fejer, J. A., and Miles, J. W., "On the stability of a plane vortex sheet with respect to three-dimensional disturbances", J. Fluid Mech., 15, 335-336, 1963.

Fejer, J. A., "Theory of auroral electrojets", J. Geophys. Res., 68, 2147-2157, 1963.

Fejer, J. A., "Hydromagnetic reflection and refraction at a fluid velocity discontinuity", Phys. Fluids, 6, 508-512, 1963.

Fejer, J. A., and Dessler, A. J., "Interpretation of Kp index and M-region geomagnetic storms", Planet. Space Sci., 11, 505-511, 1963.

Fejer, J. A., "Hydromagnetic stability at a velocity discontinuity between compressible fluids", Submitted to Phys. Fluids in January and in revised form in July, 1963.

Fejer, J. A., "Theory of Geomagnetic disturbance variations", Submitted to J. Geophys. Res. (July 1963).

Fejer, J. A., "Scattering of electromagnetic waves by a plasma cylinder", Submitted to Phys. Fluids (July 1963).

Hanson, W. B., "Electron temperatures in the upper atmosphere", Space Research III, North Holland Publishing Co., 1962.

Hanson, W. B., and Patterson, T. N. L., "Diurnal variation of the hydrogen concentration in the exosphere", Planet. Space Sci., in press, 1963.

Johnson, F. S., "Physics of the atmosphere and space", Astronautics, November, 1962.

Johnson, F. S., "Atmospheric structure", Astronautics, August, 1962.

Patterson, T. N. L., Johnson, F. S., and Hanson, W. B., "The distribution of interplanetary hydrogen", Planet. Space Sci., in press, 1963.

Rao, U. R., McCracken, W. G., and Venkatesan, D., "Asymptotic cones of acceptance and their use in the study of the daily variation of cosmic radiation", J. Geophys. Res., 68, (1), 345, 1963.

D. Symposia — Lectures by Visiting Scientists

1. SYMPOSIA

9/19/62 — Geopotential and Particle Orbits, F. S. Johnson
9/26/62 — Solar Radiation, F. S. Johnson
10/ 3/62 — Solar Radiation, F. S. Johnson
10/10/62 — Atmospheric Chemistry and Composition, F. S. Johnson
10/17/62 — Atmospheric Structure, F. S. Johnson
10/24/62 — Atmospheric Structure, F. S. Johnson
10/31/62 — Atmospheric Structure, F. S. Johnson
11/ 7/62 — A. - Heat Conduction in the Upper Atmosphere; B. - Escape of Gases from the Upper Atmosphere; C. - Particle Distributions in the Absence of Collisions, T. N. L. Patterson
11/28/62 — The Earth's Ionosphere, W. B. Hanson
12/ 5/62 — The Earth's Ionosphere, W. B. Hanson
12/12/62 — Radio Wave Propagation, J. A. Fejer
12/19/62 — Radio Wave Propagation, J. A. Fejer
1/ 9/63 — Static Geomagnetic Field, A. J. Dessler
1/16/63 — Hydromagnetics, A. J. Dessler
1/23/63 — Atmospheric Tides and Associated Magnetic Effects, J. A. Fejer
1/30/63 — Solar Wind and Configuration of Earth's and Sun's Magnetic Field, A. J. Dessler
2/ 6/63 — Geomagnetic Storms and Transient Variations, A. J. Dessler
2/13/63 — Cosmic Radiation Physics, K. G. McCracken
2/20/63 — Cosmic Radiation Physics, K. G. McCracken
2/27/63 — Van Allen Radiation, A. J. Dessler
3/20/63 — The Airglow, T. N. L. Patterson
3/27/63 — The Distribution of Interplanetary Hydrogen, T. N. L. Patterson, F. S. Johnson, and W. B. Hanson
4/ 3/63 — Auroras, F. S. Johnson

2. LECTURES BY VISITING SCIENTISTS

Dr. Brian O'Brien — Survey of Van Allen Radiation Belt, September 17, 1962
Diurnal Variation in the Van Allen Radiation, September 18, 1962
Department of Physics and Mathematics,
State University of Iowa, Iowa City, Iowa

Dr. Ian Axford — Pre-Sudden Commencement Polar-Cap Radio-Absorption, October 9, 1962
— Motions of the Magnetosphere, October 10, 1962
Theoretical Studies Group, Defense Research Board, Ottawa, Canada

Dr. Harold Liemohn — Whistler Attenuation by Electrons with an $E^{-2.5}$ Distribution, November 26, 1962
Boeing Research Laboratories, Seattle, Washington

Dr. A. M. Lenchek — Geomagnetically Trapped Radiation, Part 1, December 6, 1962
— Geomagnetically Trapped Radiation, Part II, December 7, 1962
University of Maryland, College Park, Maryland

Dr. Donald Rapp — Ionization of Diatomic Molecules by Electron Impact, December 7, 1962
Lockheed Missiles and Space Company, Palo Alto, Califorina

Dr. Edward Anders — What We Have Learned from Meteorites, December 14, 1962
Enrico Fermi Institute for Nuclear Studies,
University of Chicago, Chicago, Illinois

Dr. M. B. McElroy — Fluorescence by Solar Ionizing Radiation, May 8, 1963
Theoretical Chemistry Institute, University of
Wisconsin, Madison, Wisconsin

E. Papers Presented at Scientific Meetings

Bartley, W. C., Cosmic ray instrumentation, SWIRECO, Dallas, Texas, April, 1963.

Fejer, J. A., Theory of auroral electrojets, URSI, October, 1962.

Fejer, J. A., Hydromagnetic stability at a fluid velocity discontinuity, National Academy of Sciences, December, 1962.

Fejer, J. A., Ionospheric currents associated with the diurnal magnetic variations, American Geophysical Union, April, 1963.

Flowerday T. W., An instrument for measuring ion composition of the upper atmosphere, SWIRECO, Dallas, Texas, April, 1963.

Hanson, W. B., Diurnal variation of the exosphere, NATO Advanced Study Institute on Electron Density Profiles in the Ionosphere and Exosphere, Skeikampen, Norway, April, 1963.

Hanson, W. B., and Patterson, T. N. L., Diurnal variation of hydrogen concentration in the exosphere, Spring URSI, Washington, D.C., April, 1963.

Hanson, W. B., Sharp, G., and McKibbin, D. D., Some ionospheric measurements with satellite-borne ion traps, Spring A.G.U., Washington, D. C., April, 1963. Also presented at COSPAR Meeting, Warsaw, Poland, June, 1963.

Johnson, F. S., Composition changes in the upper atmosphere, NATO Advanced Study Institute on Electron Density Profiles in the Ionosphere and Exosphere, Skeikampen, Norway, April, 1963.

Johnson, F. S., Meteorological data above 60 km, AAAS Meeting, Philadelphia, December, 1962.

Liemohn, H. B. and Scarf, F. L., Electron energy and density distributions in the exosphere, AGU, April, 1963.

Liemohn, H. B., Thermal cutoffs of the whistler mode of propagation, SWIRECO, Dallas, Texas, April, 1963.

McCracken, K. G., Propagation of cosmic rays through the solar system, American Physical Society, Houston, Texas, March, 1963.

Patterson, T. N. L., Helium ions in the upper atmosphere, Gaseous Electronics Conference, Boulder, October, 1962.

Patterson, T. N. L., Johnson, F. S., and Hanson, W. B., The distribution of interplanetary hydrogen, COSPAR Symposium, Warsaw, June, 1963. Also presented by F. S. Johnson at URSI Meeting, Washington, D.C., April, 1963.

Rao, U. R., McCracken, K. G., and Vankatesan, D., Asymptotic cones of acceptance and their use in the study of diurnal variation of cosmic rays, Midwest Cosmic Ray Conference, Minnesota, Fall, 1962.

F. Staff

Jon G. Ables (graduate student, Oklahoma State University) M.S.

H. S. Ahluwalia (Research Associate) Ph.D.

William C. Bartley (Electronics Scientist) M.S.

Richard Bickel (Electronics Engineer) B.S.

Alexander J. Dessler (Professor) Ph.D. resigned, February, 1963

W. D. Deering (Research Associate) Ph.D. Pend. (10-63)

S. S. Degoankar (Research Associate) Ph.D.

Jules A. Fejer (Professor) D.Sc.

Thomas W. Flowerday (Research Scientist) M.S.

Benjamin Gottlieb (Research Associate) Ph.D.

William B. Hanson (Professor) Ph.D.

W. J. Heikkila (Associate Professor) Ph.D.

Olav Holt (Research Assistant) Ph.D. Pend. (10-63)

Francis S. Johnson (Division Head and Professor) Ph.D.

Harold B. Liemohn (Assistant Professor) Ph.D.

Kenneth G. McCracken (Professor) Ph.D.

James E. Midgley (Research Associate) Ph.D.

Thomas N. L. Patterson (Assistant Professor) Ph.D.

Gilbert N. Plass (Professor) Ph.D.

U. R. Rao (Research Associate) Ph.D.

B. A. Tinsley (Research Associate) Ph.D. Pend. (10-63)

W. Frank Watkins (Electronics Technician)

William C. Wilkins (Electronics Technician)

Report of the Laboratory of Earth and Planetary Sciences

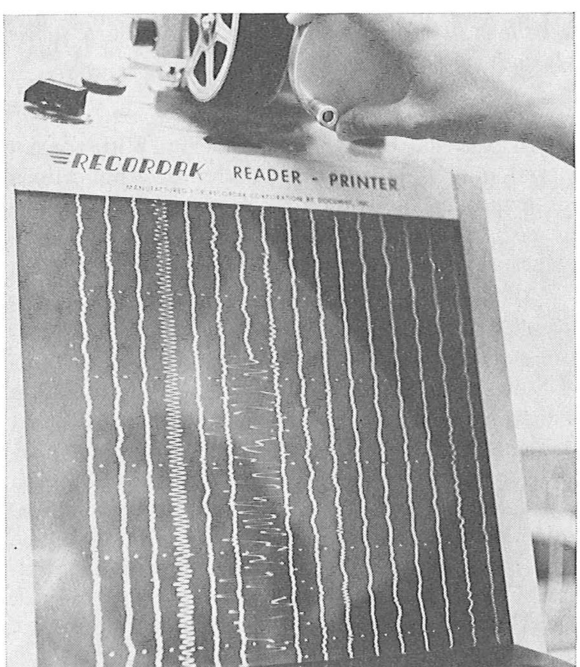
Southwest Center for Advanced Studies

Program of the Geosciences Division

A. General Objective

The objective of the research program of the Geosciences Division has been defined broadly as an attempt to make a contribution to an understanding of the processes by which the Earth has developed to its present state.

In spite of the tremendous activity in Earth science research over the past few decades, there are many questions of Earth history to which only the most speculative of answers can be given today. Such questions are: How the continents have evolved; in what way the continents differ from the oceans; whether the oceans have always been oceans; whether the continents have drifted, and whence came the energy for the mountain building cycles of the past. Such questions cannot now be answered with certainty.



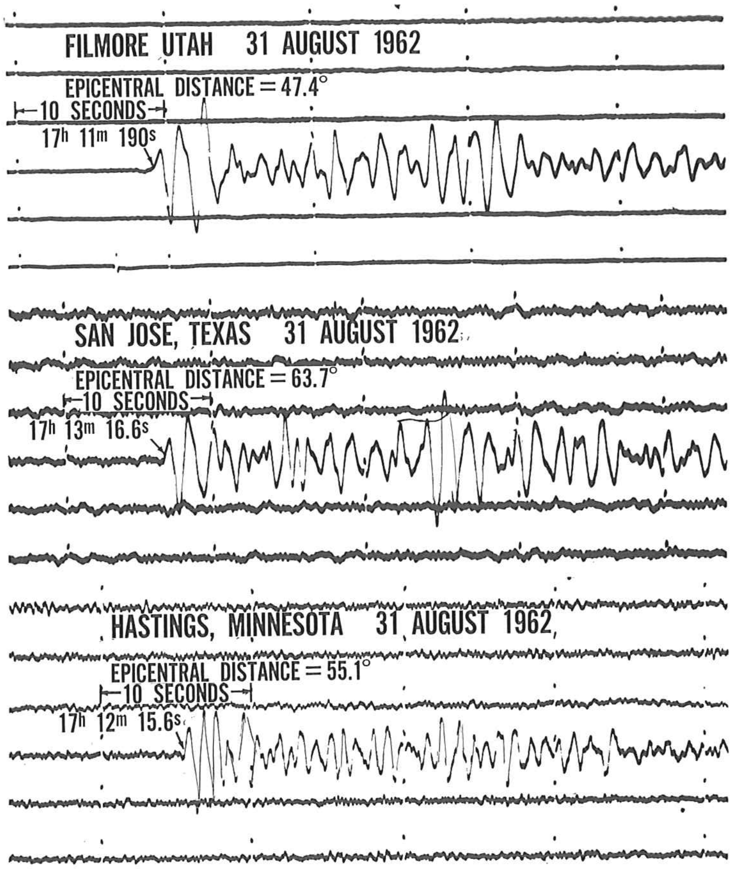
Copy of earthquake record on microfilm used in seismic analysis.

The philosophy underlying the research program of the Geosciences Division is to build up a number of small groups, each working in its own field, but actively co-operating with other groups within the Division, so that the attack on the problems of Earth sciences is as broadly based as possible. Real progress in the understading of the development of the Earth can only be made by the synthesis of information from different geophysical techniques.

There are many examples of the way in which information from one discipline may be used to complement that from another. One striking example is the use of gravity data, combined with seismic refraction data in studies of crustal structure, both on land and at sea. Another occurs in the study of the fossil magnetism of rocks of Pre-Cambrian age. These rocks constitute more than three-quarters of the geological record. The only possible method of correlation is through dating the rocks by one of the several radioactive decay schemes. In general, there is great need of correlated programs in paleomagnetism and geochronology.

Still another example is in the study of the interior of the Earth. There, velocities determined from the records of earthquakes are combined with laboratory measurements of the velocities under high pressure in order to identify the kinds of

31 AUGUST 1962
ORIGIN TIME = $17^h\ 02^m\ 43.4^s$ (G.C.T.)
LOCATION = 51.3N, 179.7W
(Rat Is., Aleutian Islands)



Comparison of travel times to three recording points, for earthquake originating in Rat Islands, Aleutian Islands, Alaska.

material which occur in the mantle. These studies combine with investigations of the composition of the solar system, meteorites, and solid state theory studies of the behavior of materials under conditions of extreme pressure and temperature.

B. Specific Research Projects

1. SEISMOLOGY

The Air Force Cambridge Research Laboratories have provided support for a study of the travel times of body waves at arc-distances of 30 degrees and upwards, based on the records obtained by the seismic network operated by the Geotechnical Corporation under contract with ARPA. The Geotechnical Corporation network is especially suitable for studies of this kind because there are a large number of stations operating at any one time, the instruments at all stations are identical, and the time is very accurate.

The principal investigator under this grant is Prof. A. L. Hales; he is assisted by Dr. John Cleary, formerly of the Department of Geophysics, Australian National University, Canberra. With the co-operation of the Air Force Technical Applications Command and the United Electrodynamics Corporation Analysis Center, copies of records of earthquakes have been obtained and are being analyzed.

During the summer of 1963, a co-operative seismic study of crustal structure in the Lake Superior region was undertaken by a number of United States and Canadian institutions. Co-ordination of the program was provided by Dr. John Steinhart of the Department of Terrestrial Magnetism, Carnegie Institution of Washington. A series of 82 high explosive shots were detonated on the lake bottom, from the Coast Guard cutter "WOODRUSH". The Center was awarded a grant from the National Science Foundation for participation in the project, with Professor Hales as principal investigator.

A Geosciences Division team set up three stations on the Bayfield (Wisconsin) Peninsula, on the south shores of the Lake. Two of the stations were equipped with three nine-element arrays and the third station with two nine-element arrays. Twenty preamplifiers and 80 amplifiers were built for this project in the Division's laboratory workshop.

The Geosciences Division investigations were directed at: (1) refraction studies of crustal structure, and (2) a study of the possibility of obtaining reflections from the Mohorovicic discontinuity at angles of incidence less than the critical angle.

One of the difficulties in seismic studies of crustal structure lies in the inherently low resolution of the refraction procedure. For this reason the Division stations were so placed that a number of the shots were at distances appropriate to investigate the possibility of detecting reflections from the Mohorovicic discontinuity.

In addition, with the co-operation of the Science Services Division of Texas Instruments Incorporated, that division set up an array of digital recorders so that computer analysis procedures devised by TI could be applied to the search for reflections.

In spite of some difficulties arising from lightning and atmospherics, all stations were in action for all shots and more than 4,000 individual records were obtained. In addition, the TI team made recordings of all but the most distant shots.

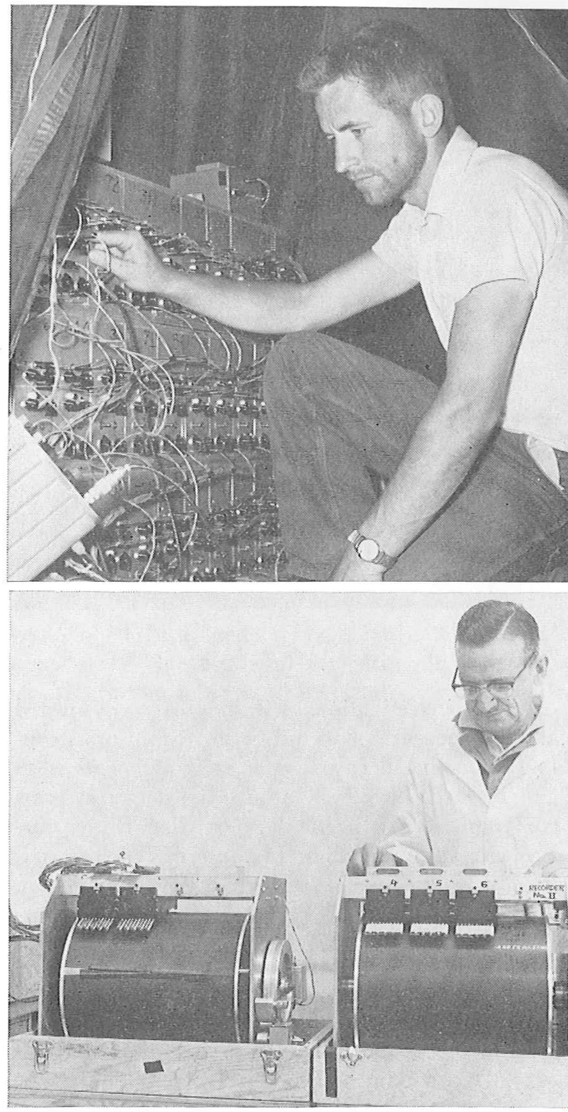
It is expected that analysis of the records will take at least a year.

2. PALEOMAGNETISM

Prof. John Graham has been awarded a grant by the National Science Foundation for the construction of an astatic resonance magnetometer. This magnetometer will have a sensitivity several times greater than any magnetometer presently used for paleomagnetic studies. The increased sensitivity will be particularly important in the study of the stability of the direction of magnetization of weakly magnetized sediments under a-c demagnetization.

Alternating current demagnetization has been used extensively to investigate the stability of the magnetization of igneous rocks and strongly magnetized sediments; it has not been applied to weakly magnetized rocks because, as demagnetization proceeds, the intensity tends to decrease to an extent that makes accurate measurements impossible with existing equipment.

Prof. Charles E. Helsley began a study of magnetic reversals of red sediments in the Chugwater in Wyoming during the 1963 summer. He also collected specimens from the Duluth gabbro as a start towards a study of the paleomagnetism of the



Amplifiers for crustal study recordings, Lake Superior region (above). Recorders used at field site (below). All equipment constructed in Geosciences Division.

1200 million-year-old Pre-Cambrian rocks of North America.

3. GEOCHRONOLOGY

Prof. Henry Faul is at present engaged in the construction of a 12-inch solid source mass spectrometer with which an extensive program will be initiated to study the geological ages of selected rocks through radio-active decay measurements. The initial steps of design and construction are being carried out in Washington, with the co-operation of the staff of the mass spectrometer division of the National Bureau of Standards.

Prof. Anton L. Hales, Head, Geosciences Division.

Initial investigations will be directed toward total rock measurements using the rubidium-strontium radioactive decay scheme, although extension of the research to other radioactive decay systems is contemplated. In particular Dr. Glen Riley, currently with the Australian Institute of Nuclear Science and Engineering, will join the Division in early 1964 to undertake geochronology studies using the rhenium-osmium decay system.

During the year equipment for the determination of the uranium and thorium content of rocks was built and tested during the visit of Dr. Robin Cherry, Department of Physics, University of Cape Town. A systematic study will be initiated during the coming year.

4. TILTMETER STUDIES

The Geosciences Division has received a grant from the National Science Foundation for the construction of tiltmeters for measuring the response of the earth to surface loading. Preliminary studies of the instrumentation requirements are now being made. Professor Hales is principal investigator in this program.

5. HEAT FLOW STUDIES

Dr. John Reitzel will join the staff of the Division in September, 1963. Initially, Dr. Reitzel will be concerned with the development of equipment for the measurement of heat flow in deep lakes.

C. Publications

Faul, Henry and Jager, Emilie, "Ages of some granitic rocks in the Vosges, the Schwarzwald, and the Massif Central," J. Geophys. Res., 68, 3293-3300, 1963.

D. Symposia — Lectures by Visiting Scientists

Dr. J. Tuzo Wilson — Have the Continents Moved? February 19, 1963
Institute of Earth Sciences, the University of Toronto

R. C. McQueen — Shock Wave Techniques for Measurement of Properties of Materials at Very High Pressures, June 11, 1963
Los Alamos Scientific Laboratories

E. Papers Presented at Scientific Meetings

Hales, Anton L., Information from Surface Waves and Heat Flow Measurement, Joint meeting Texas Academy of Science and National Academy of Sciences, Austin, Texas, November 30, 1962

F. Staff

Selwyn Bloch (Research Associate) B.Sc. (12-63)
John R. Cleary (Research Associate) Ph.D.
Henry Faul (Professor) Ph.D.
D. Ian Gough (Associate Professor) Ph.D. (1-64)
John W. Graham (Associate Professor) Ph.D.
K.W.T. Graham (Research Associate) Ph.D. (1-64)
R.W.E. Green (Research Associate) Ph.D. Pend. (12-63)
Anton L. Hales (Division Head and Professor) Ph.D.
Charles E. Helsley (Assistant Professor) Ph.D.
J. A. Keiller (Instrument Engineer)
Mark Landisman (Professor) Ph.D. (1-64)
James R. Morphew (Electronics Technician)
John Reitzel (Research Associate) Ph.D. (9-63)
G. H. Riley (Research Associate) Ph.D. (3-64)
Ellis W. Shuler, Jr. (Electronics Engineer)
John Verhoogen (Consulting Professor) Ph.D.
George W. Wetherill (Consulting Professor) Ph.D.

Report of the Laboratory of Earth and Planetary Sciences

Southwest Center for Advanced Studies

Program of the Mathematics and Mathematical Physics Division

A. General Objective

The transcendent importance of a strong group in mathematics and theoretical physics was recognized early in the development of the Center. Not only are such studies of great significance in themselves, but they stand *in loco parentis* to the development of other, less abstract, sciences and to the technology based on modern science.

One aspect of theoretical physics with which the Center has been largely concerned is the general theory of relativity. This theory, which was conceived by Einstein almost 50 years ago, represents at present the only satisfactory and fundamental approach to gravitation, one of the basic force fields of physics. Its future development is important as a scientific pursuit, in that it is likely to lead to insights significant beyond the confines of gravitation.

As for useful applications, the bearing of gravitational theory to man's exploration of space at this time is conjectural. Both the United States Air Force and the National Aeronautics and Space Administration are making a moderate investment in relativity research. It would be irresponsible to claim that successful research in relativity will help man to first-hand space explorations, but it does seem reasonable to expect that scientific strength in this area will be of significant help once extraterrestrial research stations are established to accomplish scientific experiments impossible to perform on the ground.

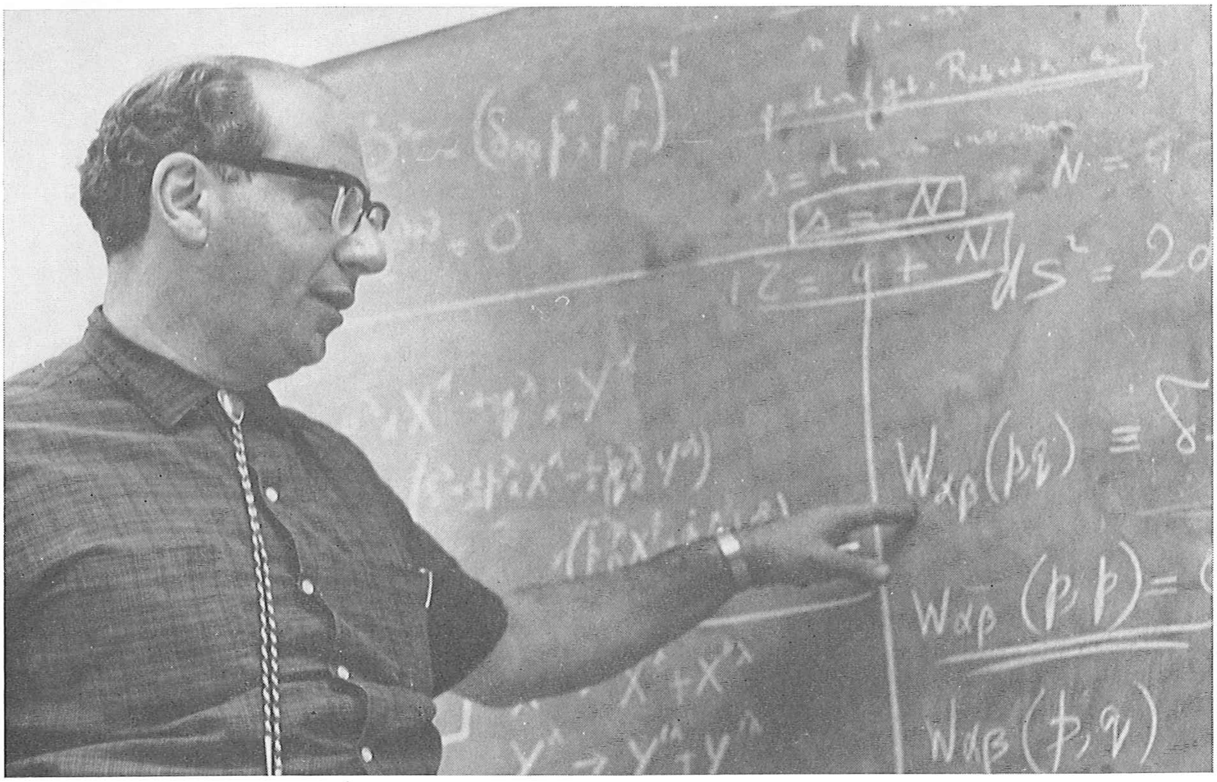
The number of scientists working in this field has increased enormously in the past 10 years, but it is still comparatively small; there are perhaps 150 active research workers in general relativity in the whole world. In terms of national affiliation, the numerically largest and scientifically strongest groups are found in the United States, Great Britain, France, Poland, West Germany, and the Soviet Union. At recent international conferences, both in France in 1959 and in Poland in 1962, the delegation from the United States comprised the largest single national delegation, contributing perhaps one quarter of the total attendance.

Research in general relativity in Texas dates back only a few years. It began with the efforts of Prof. Alfred Schild to build up his group at the University of Texas, Austin. The ties between his group and the Southwest Center for Advanced Studies are close.

B. Specific Research Projects

It appears that the Southwest Center for Advanced Studies will be able to make a significant contribution to this very important field of scientific research. Nine scientists are now working on problems of general relativity. Prof. Ivor Robinson, Dr. Joanna Ryten Zund and Mr. Joseph Zund are looking for the most general solution to Einstein's equations for empty space admitting a shear-free vector field which twists and diverges.

Prof. Michel Cahen is investigating null congruences in general; he is also examining solutions of the empty space equations in which the principle null directions are equianharmonic. Prof. Istvan Ozsvath has constructed, and is examining in detail, two classes of universes, the intersection of which is the Godel universe. Mr. Christoph Behr and



Prof. Ivor Robinson, Head, Mathematics and Mathematical Physics Division.

Mr. David Farnsworth are working on cosmological problems, also Prof. Manfred Trumper is investigating the motion of non-spinning test particles in general relativity.

Prof. Engelbert L. Schucking has made a number of contributions of great interest and importance to the work of the group along several lines, including both gravitational radiation and cosmology. Prof. Fred N. Holmquist is continuing his investigation in electromagnetic theory.

C. Publications

None

D. Symposia

There is a bi-weekly seminar, open to the public, on general relativity and related subjects.

E. Staff

Christoph Behr (graduate student, University of California) M.A.

Michel Cahen (Visiting Associate Professor) Ph.D.

David Farnsworth (graduate student, The University of Texas) M.A.

Fred N. Holmquist (Assistant Professor) Ph.D.

İstvan Ozsvath (Associate Professor) Ph.D.

Ivor Robinson (Head of Division and Professor)

Wolfgang Rindler (Associate Professor) Ph.D.

Engelbert L. Schucking (Visiting Professor) Ph.D.

Manfred Trumper (Visiting Associate Professor) Ph.D.

Joanna Ryten Zund (Research Associate) Ph.D.

Joseph Zund (graduate student, The University of Texas) M.A.

Report of the Laboratory of Earth and Planetary Sciences

Southwest Center for Advanced Studies

Magnetic Facility, Dallas Magnetic Observatory

Under the general scientific supervision of the Laboratory of Earth and Planetary Sciences, this facility has been in operation since July 11, 1963. At that time, dedication ceremonies pointed up the unique character of this installation and its operation. Some 25 acres of land necessary to assure a quiet magnetic environment were allocated by SCAS to accommodate a complex of buildings which were erected by Texas Instruments and dedicated to the Center. The design of the buildings was developed in co-operation with the U.S. Coast and Geodetic Survey, which has instrumented and is operating the Dallas Magnetic Observatory. The observatory provides round-the-clock recording of fluctuations in the vector components in the Earth's magnetic field, as well as absolute values of the Earth's magnetic components. A central building in which these records are developed is also suitable for housing experiments involving magnetic measurements at low levels.

Special designs and very careful construction techniques were employed in the development of this facility in order to assure freedom from ferromagnetic objects and consequent magnetic anomalies. A previous survey had shown that this location was characterized by low ambient magnetic noise, natural and man-made, that the magnetic gradient over the area was small, and that 60-cycle fields were negligible.

In addition to the observatory work there is currently under way a measurements program to evaluate several varieties of magnetometers. In conjunction with Texas Instruments and Texas Christian University, the Laboratory of Earth and Planetary Sciences plans to conduct a sponsored experimental project on telluric currents starting this fall. Planned for late fall or early 1964, in co-operation with the same groups, is a project on micropulsation studies which will involve the construction of a facility to house physically large detection coils. There is every evidence that a multiplicity of similar magnetic projects will develop within the laboratory as its research program unfolds.

Staff

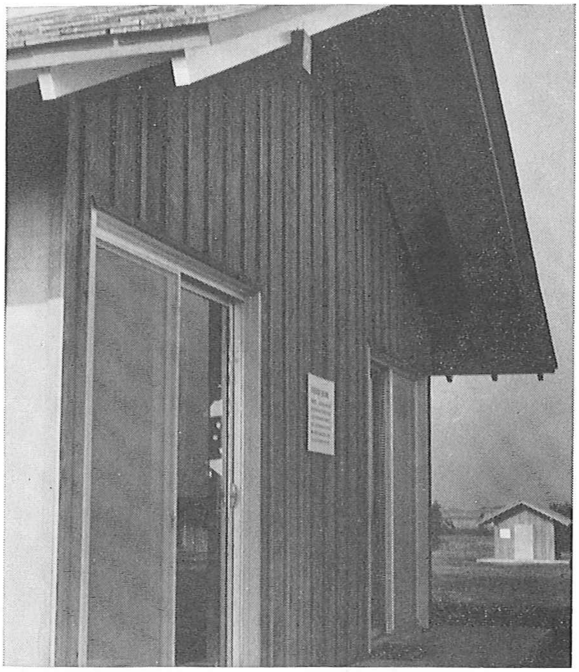
C. Frank Seay, Jr. (Acting Manager)

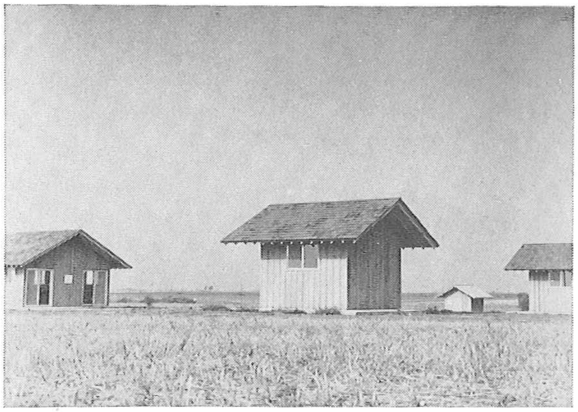
Lieut. Lavon Posey, U.S. Coast and Geodetic Survey

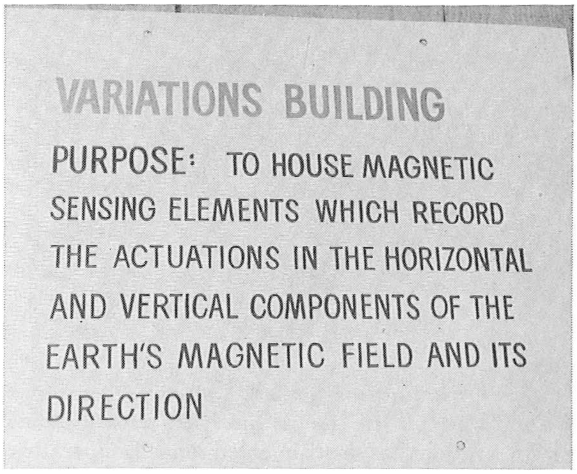
A. D. Anderson, U.S. Coast and Geodetic Survey

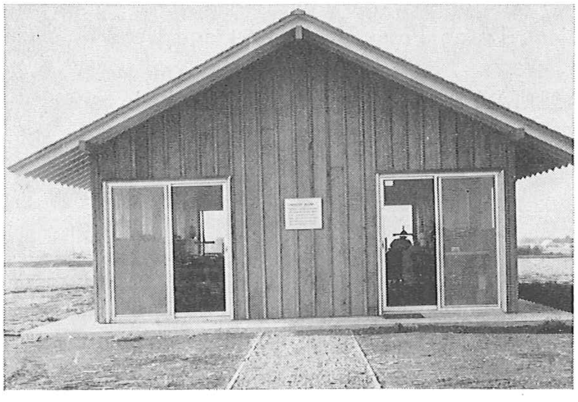
ON FOLLOWING PAGE — General views of Magnetic Facility and Dallas Magnetic Observatory, on the Southwest Center for Advanced Studies campus. Location is approximately 18 miles north of downtown Dallas, within the city limits of Richardson, Texas.

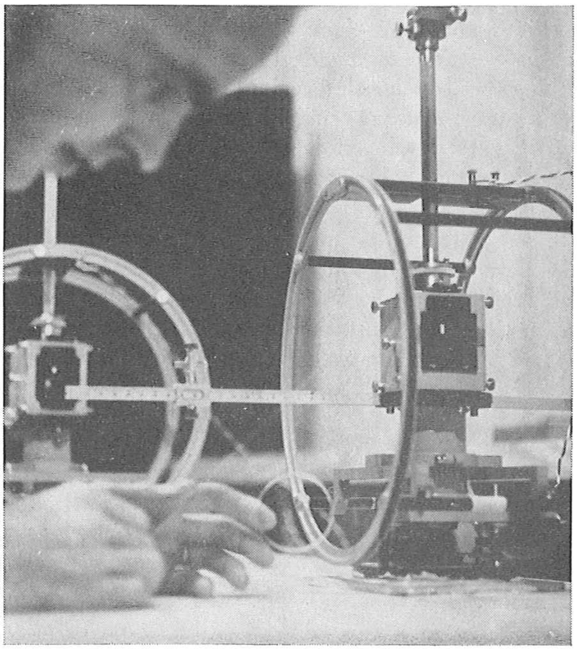
General views of Magnetic Facility and Dallas Magnetic Observatory. At bottom, right, magnetic variometers for continuous recording of variations.











3- Investigation of Radiology with Pi Mesons (Pions)

Southwest Center for Advanced Studies

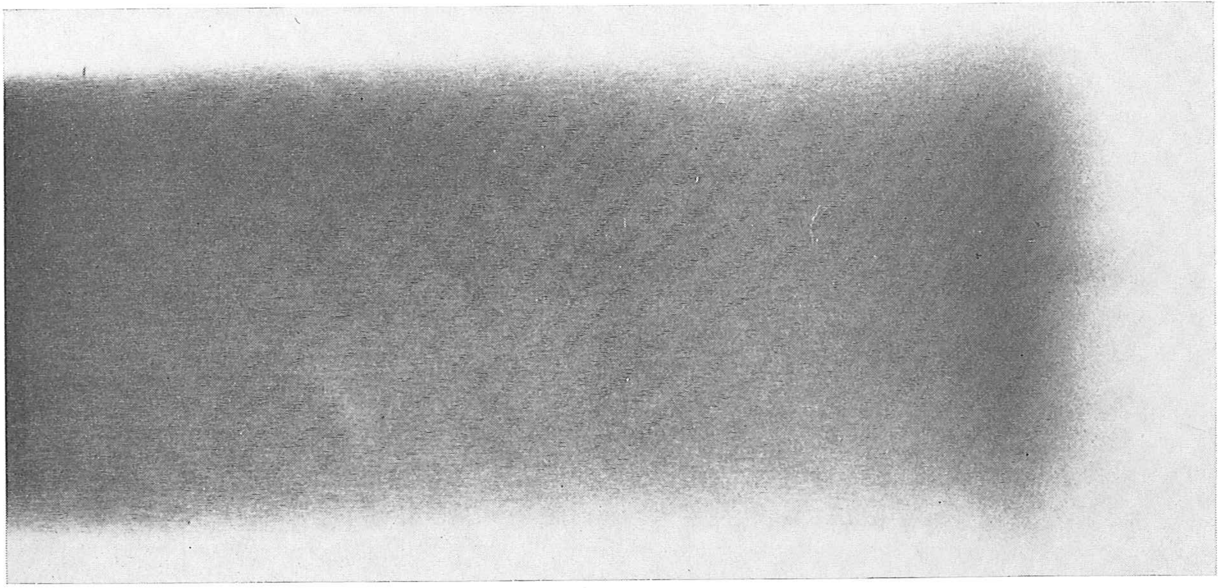
The pi meson, a nuclear particle first discovered in cosmic rays, is now produced abundantly by high energy machines in the laboratory. In addition to its interesting nuclear characteristics, it has certain remarkable biological properties. It destroys cells at the end of its path, while inflicting relatively little damage to cells along its path. This unique ionization peaking feature holds unusual promise for radiation therapy. A great many problems must be solved, however, before this radiation can be used for human carcinoma.

Under support from the American Cancer Society, Prof. Chaim Richman is now undertaking the first phase of an experimental program with negative and positive pi mesons. Initial experiments have been conducted at the Lawrence Radiation Laboratory, University of California, with the co-operation of the staff of the Radiation Laboratory. Preliminary investigations have utilized phantoms with elements of low atomic number, in sandwiches of approximately unit density material, to obtain dosimetric measurements and to study the distribution of dosage around the beam. Subsequent experiments will lead to finer and more detailed investigations and eventually to biological experiments.

Staff

Chaim Richman (Professor) Ph.D.
Henry Aceto (Graduate Student, Southwestern Medical School, The University of Texas) M.S.

Photographic record of Pi Meson beam (80 Mev) with ionization peak at eight-inch depth in lucite.



4- Laboratory of Computer Sciences

Southwest Center for Advanced Studies

Objectives and Program

Plans call for the establishment of a new Laboratory of Computer Sciences as a part of the program of the Southwest Center for Advanced Studies. The Laboratory will initially consist of two divisions. One division will be the Southwest Data Processing Center, which will make available — to both scientists of The Graduate Research Center of the Southwest and universities of the Southwest — computing and data processing facilities with speed and capacity greater than that ordinarily available to universities in the region. The other division will be the Division of Mathematical and Stochastic Systems, which will engage in research in those mathematical areas generally recognized as being associated with Computer Sciences.

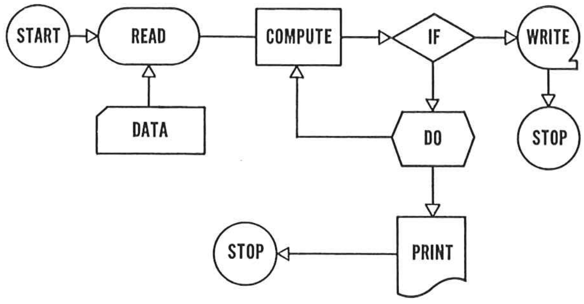
Initially, the Laboratory will be housed in Research Building Nȯ. 1 (refer to Campus Development); however, plans call for the construction of a separate facility which will house both the Southwest Data Processing Center, as well as the research division. Space will be available for research offices and laboratories; programming, conference and class rooms, including research office space available for regional scientists when they are in residence for the purpose of using the computing facility.

Co-operative arrangements are envisioned relative to the exchange of staff and programs with the other computing centers of the Southwest.

The research program of the Laboratory will be developed around those mathematical areas that are generally associated with computer sciences. Areas that are presently included are: Stochastic Processes, Numerical Analysis, Sampling and Survey Theory, and Information Retrieval Theory. Emphasis will be given to combinational and finite mathematical concepts in the research programs in these and other related research projects.

Staff

Dr. Carl F. Kossack (Acting Director) Ph.D.



5- Laboratory of Molecular Sciences

Southwest Center for Advanced Studies

Objectives and Program

The Laboratory of Molecular Sciences is being organized to explore the fast-advancing borderline domains in which the physical and biological sciences overlap. The approach will be primarily that of the physicist and chemist, with the essential collaboration of the biologist, utilizing the new techniques of molecular biology to conduct fundamental research in this field.

Groups are expected to develop in this Laboratory around scientific leaders who will direct work in cell biology, biochemistry, biophysics, and molecular quantum dynamics. These programs are to be supported and supplemented by the efforts of other scientists employing the techniques of applied mathematics and utilizing the services of Laboratory of Computer Sciences and special instrumentation groups.

A primary factor in the program will be the study of complex organic crystalline substances and the long-chain protein molecules. The techniques of electron spin resonance, nuclear magnetic resonance, electron microscopy, and the mathematical methods of quantum dynamics will constitute useful and sometimes necessary tools in such work. Many of these purely physical structures at the atomic and molecular level are closely allied to living matter. Research of this kind should lead to better understanding of the nature of living structures, genetic processes, and possible steps in evolution.

The research will be basic in nature and oriented toward the frontiers of knowledge about cell structure, the differentiation of inanimate and living material, and the varying degrees of organization of the latter. This kind of investigation relates directly to many areas of the excellent medical research in progress at Southwestern Medical School and Wadley Research Center in Dallas, and at the centers of medical education at Houston and Galveston. It is also quite likely that certain phases of the Laboratory's research program will find direct application to biological investigations in space.

Electron micrograph of living DNA molecule (molecular weight 133 million) with unraveled spirals, or loops, resulting from heat treatment in formaldehyde.

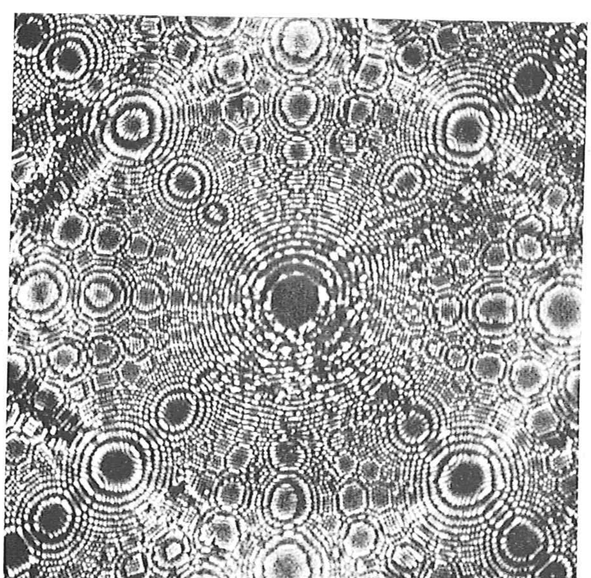
6- Laboratory of Materials Sciences

Southwest Center for Advanced Studies

Objectives and Program

Work in Laboratory of Materials Sciences will include a broad-scale program of fundamental research in such fields as low temperature physics, nuclear and electron resonance phenomena, optical and infrared spectroscopy, high pressure research, investigation of high-intensity magnetic fields, neutron spectroscopy, high temperature physics, relativistic phenomena such as the Mossbauer effect, crystallography, and new materials.

The work will, of course, also include any deserving new research area that an incoming staff member might suggest or that could grow out of the fields mentioned. Preliminary planning for this program envisages as many as 15 to 20 eminent scientists, each acting as a nucleus about whom might gather 3 to 6 other scientists in professional grades, including visiting professors and research associates.



The experimental program is planned to range from the study of new materials, such as large single crystals for improved and more efficient continuous laser operation, to high pressure and temperature phase relationships. Also to be investigated are such subject areas as the physics of thin films; physics and molecular chemistry of magnetism; transport phenomena in the solid state; low temperature work in the presence of very high magnetic fields; and the effects of very high electrical fields upon materials, as in the field ion microscope.

Among possible goals is the achievement of prototype operation of devices such as a continuous solid-state optical laser at liquid helium temperatures and high energy particle accelerator devices at superconducting temperatures. An interesting possibility, for instance, is a linear accelerator constructed of lead, designed to run at a temperature of 3 degrees absolute. The entire structure including magnets would not be over one foot in diameter or 50 feet long, for producing particle energies in excess of 100 Mev.

Which specific problems are undertaken in a field with such vast potentials is, of course, to be determined by the scope and interests of the Laboratory's scientific leadership.

Regardless of what particular fundamental problems are studied, however, experience shows that inevitably from these researches will emerge many practical aspects which will stimulate a wide range of interests within industrial and academic groups in the region.

Image from field-ion microscope showing stressed platinum crystal after recovery at room temperature.

7 - Laboratory of Electronics Sciences

Southwest Center for Advanced Studies

Objectives and Program

The Laboratory of Electronics Sciences will encompass a range of interdisciplinary activities which have appeared only recently in certain rapidly developing scientific frontiers. The possibilities offered by recent techniques in electronics will open many heretofore inaccessible fields of experimentation.

One field of immediate concern is that of bioengineering, in which area a group is already in process of formation. Here the primary aim will be to apply today's technology to the analysis and comprehension of biological organism. This new approach will investigate the medical engineering aspects of the relationships of organisms to their environment. One obvious objective is the optimization of desirable responses to an environment. Thus, one area of study will involve models to simulate neural systems and their function. Here one must investigate the manner in which information is coded and transmitted in biological systems, the sophisticated feedback loops present in neural systems, and the nature of the living process.

Other topics for investigation will include human and environmental engineering; artificial body organs and fluids; unit processes associated with medicines and foods, particularly modified foods and highly specialized medicines; sensory perceptions, especially the optical and olfactory senses and the ear labyrinth; and the effects of reduced gravitational field. These all have great relevance to man's changing environment, particularly that related to space exploration and survival on other planets.

Other laboratory interests will be information theory and the accompanying methods of data transmission, coding and handling. This field may well include the more subtle means of intelligence recognition and conveyance. Here an important factor is confusion of information, most commonly recognized as the "signal to noise" ratio. Research will extend to detection principles such as those involved in masers, parametric amplifiers and other low-noise devices as well as to data-integrating methods. Thus, many of the advanced electronic techniques having to do with transmission, reception, measurements and instrumentation — some of these in areas just beginning to be understood — are to be part of the normal function of this laboratory.

Effort in radiophysics is to be concentrated upon radio astronomy and the physics of radio communications, including measurements and instrumentation. This will involve the basic problems of transmitter, receiver, and antenna systems, ranging from very high power and large apertures to very weak signals and extreme sensitivity. Techniques of radiometry also are important in terms of ultimate achievements in probing outer reaches of the universe. Approach to these problems, of course, will include awareness of factors affecting propagation in the troposphere and ionosphere, the outer Earth and solar system environment, and the nature and content of outer space.

8- Co-operation with Regional Universities and Industry

A. General

As explained in foregoing chapters of this report, the Graduate Research Center of the Southwest, through its research and teaching arm, the Southwest Center for Advanced Studies, has as its precept the correlative advancement of graduate scientific education and research.

The emphasis in the SCAS is on training and research at the post-doctoral level in the Laboratory of Earth and Planetary Sciences, and in the other laboratories now contemplated. In addition, some pre-doctoral students at regional universities are now doing a part of their dissertation researches at the SCAS.

B. Post-Doctoral Training

Two principal types of post-doctoral training are now under way. These are further training for the new doctoral graduate, to qualify him fully for a university teaching post, and refresher or advanced work for the more experienced research worker or faculty member.

Most of the research associates now with the Southwest Center for Advanced Studies are in the first category. These doctoral graduates are generally offered two-year appointments; one-year extensions are possible under appropriate circumstances. They are selected with great care, to ensure that their work will contribute to the SCAS programs and that they will themselves profit from association with senior men in their fields.

A conscious effort is made to bring in young people from outside the region, and to acquaint them with professional opportunities in the Southwest. Measures will be taken to interest the faculties of regional colleges and universities in these young scientists upon termination of their SCAS appointments.

C. Pre-Doctoral Co-operation

Co-operation with universities at the pre-doctoral level is developing rapidly, although it necessarily involves special and individual arrangements for each of the many programs and graduate students concerned. Typical examples illustrate the variety of arrangements which together represent a significant intellectual opportunity offered by the Center.

Prof. Ivor Robinson, Head of the Mathematics and Mathematical Physics Division, and his staff are working closely with Profs. Alfred Schild and Engelbert Schuking and others at The University of Texas to develop a strong theoretical physics program in the Southwest. Several of Professor Schild's doctoral candidates have requested opportunity to work at the Center, under Professor Robinson's supervision. Professors Robinson, Schucking, and Wolfgang Rindler (of SCAS) are planning a joint investigation into gravitational radiation, predicted by theory but not yet experimentally verified.

As noted in another section of this report (Investigation of Radiology with Pi Mesons) Prof. Chaim Richman is also engaged in an association with the staff and students of the Southwestern Medical School on certain aspects of radiation therapy. Professor Richman has been asked to lecture to medical staff and students on high-energy particles. In addition, Professor Richman has been asked to counsel one student who is carring on work in proton therapy. This is related to the summer program in Pi-Meson research at the University of California in Berkeley.

A graduate student of Oklahoma State University has also come to the SCAS, to complete his research dissertation in the field of cosmic ray studies, under supervision of Prof. Kenneth G. McCracken, Atmospheric and Space Sciencies Division.

Prof. Anton L. Hales and his staff, in the Geosciences Division, are developing co-operative oceanographic programs with Prof. Dale M. Leipper of Texas A. and M., at College Station. Professor Hales has been invited to contribute programs to be undertaken aboard a vessel now under conversion for the Department of Oceanography and Meteorology. These programs will provide graduate opportunity to students at both institutions.

Faculty members of Southern Methodist University and SCAS Geosciences Division plan doctoral program in geophysics.

D. Co-operation in New Doctoral Programs

A significant development during recent months has been the establishment of a Ph.D. program in Geophysics by Southern Methodist University. The faculty of the Geosciences Division will augment the excellent geology department faculty in existence at Southern Methodist.

Five members of the SCAS faculty will teach graduate courses during the coming academic year, and will hold adjunct professor appointments on the SMU faculty. Those appointed are Professor Hales, head of the SCAS Geosciences Division; and Professors Henry Faul, John Graham, C. E. Helsley, and Dr. John Reitzel.

A similar co-operative program is under development with the Department of Physics at North Texas State University in Denton. Prof. Francis S. Johnson and the SCAS staff in the Atmospheric and Space Sciences Division will provide augmenting faculty in atmospheric physics. This will permit NTSU to offer the Ph.D. degree in this important area of physics, again with SCAS scientists holding appointments as adjunct professors.

NTSU has made application to the Texas Commission on Higher Education for approval of the Ph.D. program, with support from GRCSW.

Professor McCracken will begin teaching a course in Classical Optics at NTSU this fall.

Texas Woman's University, also in Denton, is a leader in nutritional research and food chemistry, and has developed a high competence in nuclear chemistry. A joint TWU-SCAS committee has established requirements of staff and facilities for two Ph.D. programs there. These will be in Radiation Biology and Radiation Chemistry. A joint presentation of these programs was made with NTSU at a recent meeting of the Texas Commission on Higher Education.

As the faculty of the Southwest Center for Advanced Studies expands, there will be other areas of co-operation with universities in the immediate region, including the University of Texas Southwestern Medical School in Dallas, and the University of Dallas, which has recently announced a doctoral program in engineering physics.

This program, based on a year-around undergraduate schedule, with the student achieving the bachelor's degree in physics in three years, plus three years of graduate study, will involve several members of the Center's faculty.

E. Space Seminar

Professor Johnson and his staff have presented a comprehensive lecture-seminar series in atmospheric and space sciences. This series, delivered during the past academic year on a once-weekly basis, is at graduate level; participants were drawn in large part from the aerospace and geophysical research and development staffs of companies in the Dallas-Fort Worth area.

An evening course at the graduate level will be offered by Texas Christian University in Fort Worth during the coming academic year. Based on the seminar series, the course will be offered for three semester hours' credit in the graduate college. Special non-credit attendance will also be approved for a limited number of persons. Lecturers in this course will be Profs. Jules A. Fejer, William B. Hanson, McCracken, T. N. L. Patterson, and Gilbert N. Plass, of the Atmospheric and Space Sciences Division. Topics will include atmospheric structure, the ionosphere, radio propagation, the static geomagnetic field and related subjects.

A second presentation of the seminar series will be made for faculties of local universities. The series will also be presented in Houston, with the co-operation of Rice University and the Manned Spacecraft Center, National Aeronautics and Space Administration.

The foregoing instances illustrate the pattern of co-operative activities between the Southwest Center for Advanced Studies and universities; the pattern will be enlarged and extended as other SCAS research programs are initiated.

It is significant that, with the single exception of the program of radiation therapy studies, all of these programs have been generated within the past nine to 12 months.

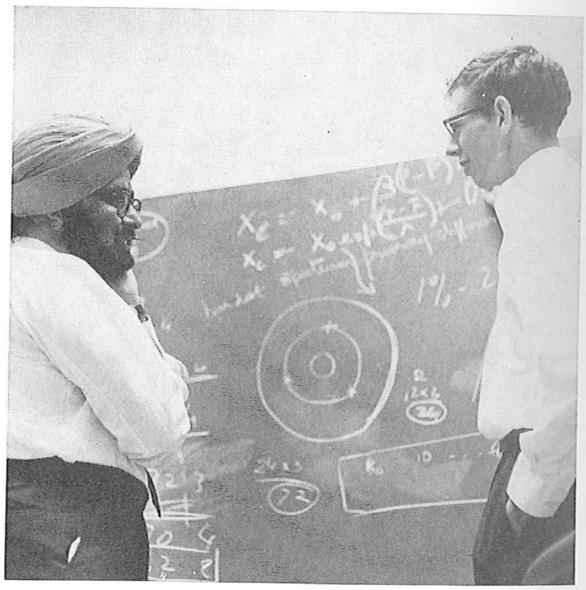
It is expected that the next year will see the addition of new co-operative seminar programs.

F. Co-operation With Industry

The Center is engaged in fundamental research, and will not undertake applied research, which is the proper concern of business and industry. The value of the Center to industry lies principally in the generation of a faculty representing the reservoirs of knowledge out of which innovation must ultimately flow.

The presence of laboratories such as those provided by the Center in the Southwest offers opportunity for scientists and industry to remain close to fundamental scientific developments out of which a broad range of technology will grow. The Center therefore presents the opportunity for qualified industrial scientists to work in its laboratories and with its faculty on the problems which are being undertaken at the Center.

Likewise, the joint activities of the faculty of the Center and of the universities, in offering graduate courses, provide to industrial scientists and engineers the opportunity for the furtherance of their post-graduate education. In addition, many of the post-doctoral students who have developed their skills at the Center will become available to industry in the development of applied research.



Dr. H. S. Ahluwalia, Research Associate, has come to the SCAS for post-doctoral study and research in the Atmospheric and Space Sciences Division. At right, Prof. Kenneth G. McCracken of the SCAS faculty.

9- Campus Development

Southwest Center for Advanced Studies

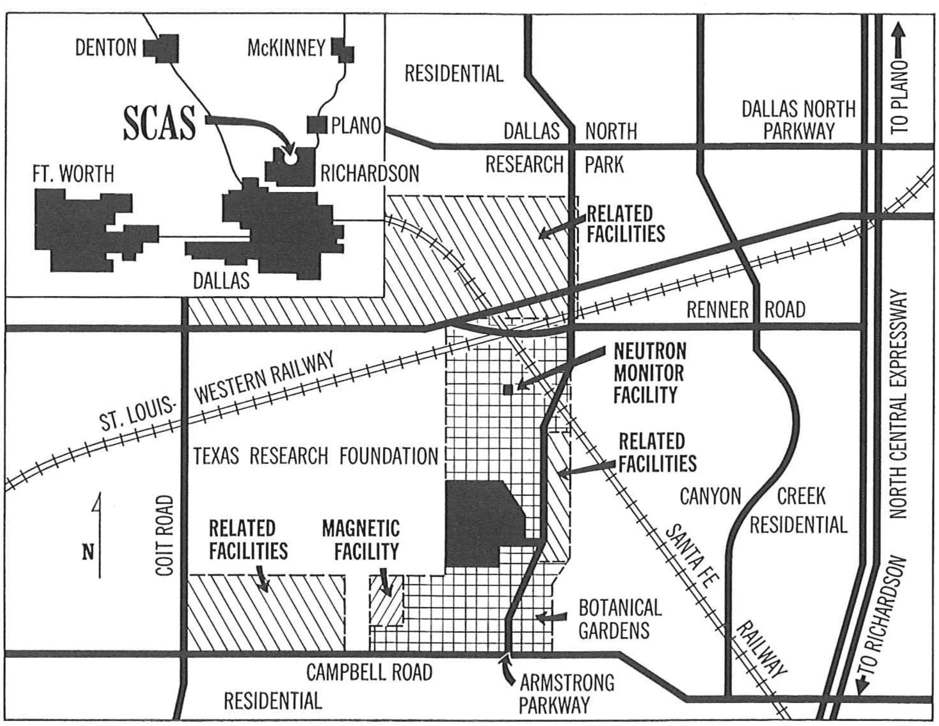
Campus Master Plan

In evolving the Master Plan for the SCAS campus, the usual factors of land utilization, site development, and building development have been under continuous consideration. Characteristic of such planning, these factors have been and are being progressively amended in details as the program unfolds, although the broad plan remains stable. In addition to these usual considerations, the planners are maintaining cognizance of the pertinence and importance of neighboring areas, as well as the Center's relations to municipal and county governments involved.

The area map shows the long-range land utilization goals for the Center's 1400 acres. Approximately 340 acres (shaded area) are delegated to the main SCAS campus, of which some 70 acres within the campus peripheral road constitute the main building complex. The land areas denoted "related facilities" are planned for applied research sites, to be occupied by industrial research laboratories, generally on long-term lease bases.

In earlier actions of the GRCSW Board, approval was given to permit sale of a portion of these "related facilities" areas to industrial concerns which have made the Center's creation possible.

Adjacent to the campus is the Texas Research Foundation on the west, Canyon Creek development



CAMPUS PLAN

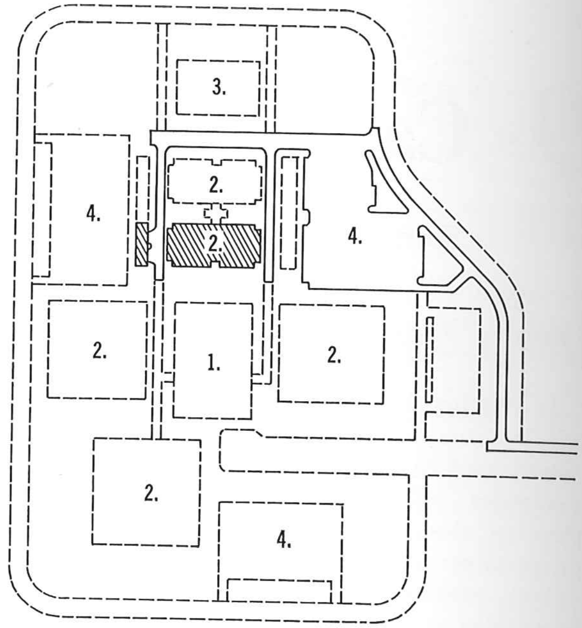
1. THE CENTER'S CORE
library, classrooms, computing center, auditorium, conference and seminar rooms, cafeteria and administrative offices.

2. RESEARCH BUILDINGS

3. POWER PLANT

4. PARKING AREA

▨ NOW UNDER CONSTRUCTION
--- FUTURE CONSTRUCTION



to the east, and Dallas North Research Park to the north-northeast.

The Texas Research Foundation has a distinguished record of applied research in the studies of grains, grasses, fiber and beef production. In addition, basic studies of the chemistry and physics of soils as they relate to seed germination and plant development have contributed to a broader understanding of regional agricultural problems. It is anticipated that the Center will maintain a close working relationship with the TRF in scientific areas of common interest, including possibly the development of a botanical garden area located in the southeast corner of the main campus.

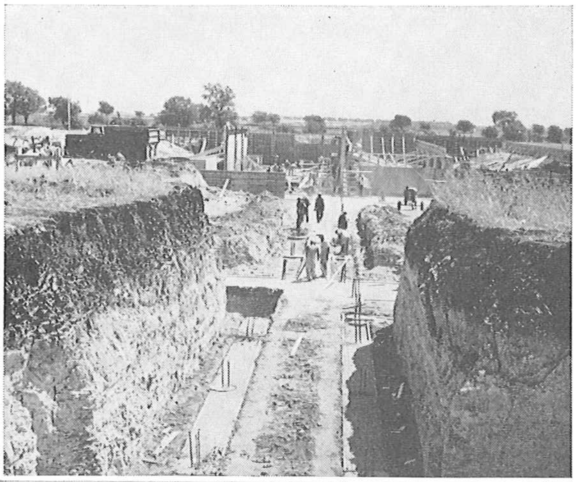
Canyon Creek is a developing residential section which includes a country club, wooded areas and winding roads and features executive-level homes of both contemporary and traditional design.

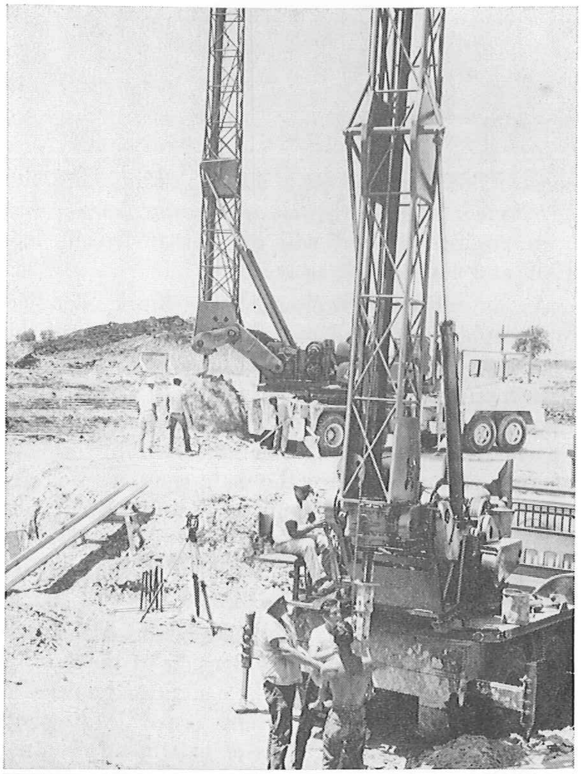
Dallas North Research Park offers desirable siting for industrial research laboratories and science-based industries seeking the advantages resulting from nearness to a fundamental research center. In addition to extensive site work already completed, this development has completed two laboratory buildings and has two more scheduled for completion during the fall of 1963. The Geosciences Division of SCAS Laboratory of Earth and Planetary Sciences will occupy over half of one of the already completed structures, made available through the generous action of two members of the Center's Advisory Council; other SCAS activities may occupy the remainder of this building as temporary quarters, awaiting the completion of the initial research building on campus.

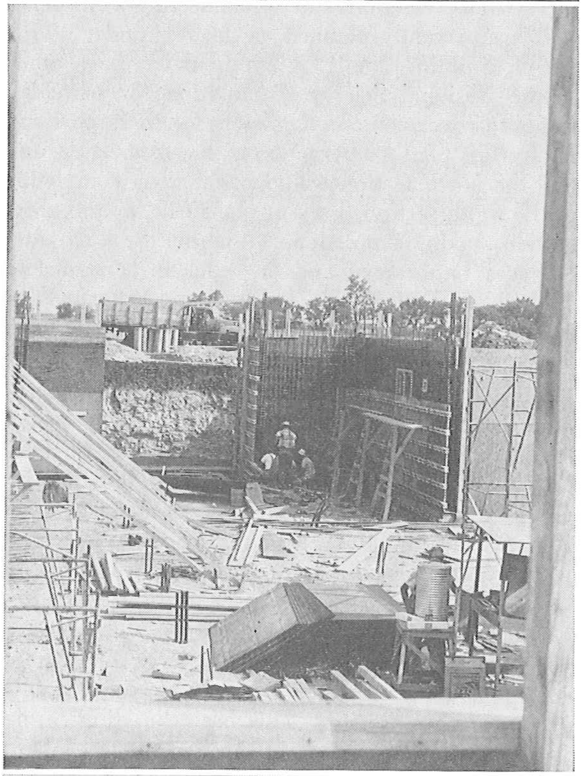
Site Development

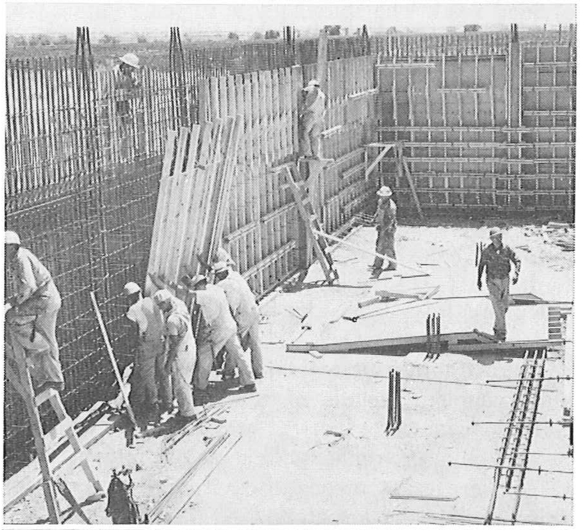
The spring and summer of 1963 have witnessed considerable activity on the main campus tract. Under the expert supervision of Forrest & Cotton, Inc., consulting engineers, the following work has been carried out: (1) the initial phase of the campus water system has been completed; (2) a thoroughly engineered storm drainage system has been finished; (3) the sanitary sewer system is approximately 75 per cent complete; (4) grading and base preparation of the entrance road and the initial portion of the campus peripheral road has been completed, and paving is scheduled for completion by mid-September; (5) gas and telephone services have been engineered and have been scheduled for

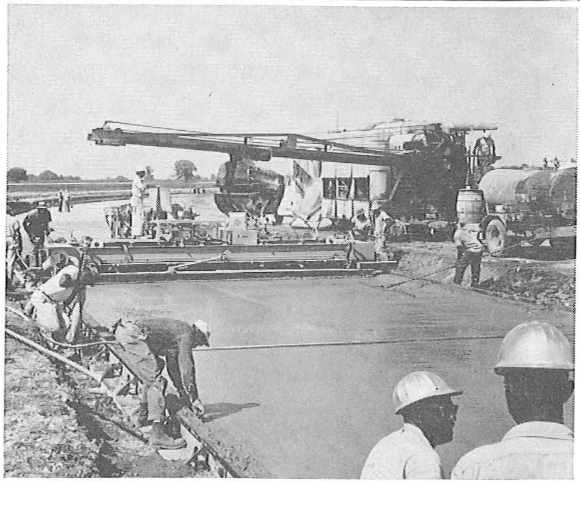
ON FACING PAGE — Construction activities at the SCAS campus site during the summer of 1963.

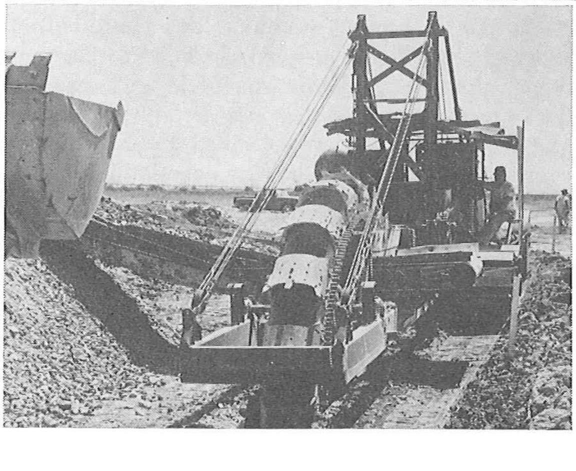












construction to mesh with other building and site developments; and (6) electric power service has been engineered and will be constructed in late 1963 and early 1964, as required.

As an adjunct to physical site work, detailed topographic maps and co-ordinate plan maps of the area have been prepared. Close co-ordination has been maintained with the City of Richardson, within whose city limits the main campus area lies. Special zoning for all Center lands within the City of Richardson, including the main campus tract and related facilities areas south of Renner Road, has been granted. Approval of the over-all site plan for these areas has been given by the Richardson City Council.

The entrance roadway, to be known as Armstrong Parkway, in its initial phase consists of the eastern half of what will eventually be a divided boulevard. Similarly, the campus entrance road leading off Armstrong Parkway consists of half of an eventual divided road. The initial phase of the campus peripheral road will extend over roughly the first (northeast) quadrant of the main campus building complex.

Building Construction

During July, 1963, the SCAS Magnetic Facility, which includes the Dallas Magnetic Observatory and a magnetic measurements facility, was completed and occupied. Details of this complex are given elsewhere in this report. The Magnetic Facility is located on approximately 25 acres of protected land, to assure a quiet magnetic environment, and comprises six special structures.

The initial campus building, the south half of Research Building No. 1, is scheduled for completion during the second quarter of 1964. Because of the urgency for space to house certain pending research programs, it was decided to expedite the construction of this building by negotiating the contract for the foundation and basement area work prior to taking bids on the main structure. Begun in late June, all work below the first floor level is scheduled for completion by mid-September.

The south section, providing approximately 90,000 square feet of usable space, will initially house the Laboratory of Earth and Planetary Sciences, the Mathematics and Mathematical Physics Division, and Administration. As part of the initial building phase, a separate annex will house the heating and refrigeration facilities to serve the south section and its companion north section, scheduled for later construction. Also in the annex initially will be a portion of the Geosciences Division operations. With the construction of additional buildings, power equipment will be moved from the annex to the permanent power plant, and the annex space will revert entirely to laboratory usage.

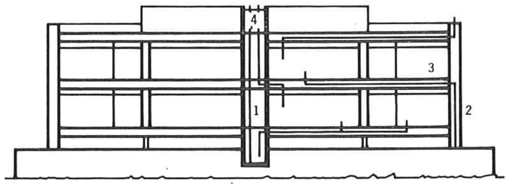
The north section and a connecting conference unit are presently planned as the remainder of Research Building No. 1. A proposal has been made to the National Science Foundation for matching funds to cover construction costs for these portions. Under this plan, construction of the connecting unit and the north section would begin upon completion of the south section. Present plans call for the north section, upon completion, to house the Computer Sciences Laboratory and the nucleus personnel of the Molecular Sciences Laboratory, Materials Research Laboratory, and Electronics Sciences Laboratory.

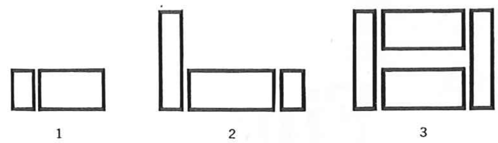
The five-year construction plan features, in addition to the five basic laboratories, a central facilities structure, the design of which is still flexible; this will form the center core of the building complex and provide space for class and seminar rooms, central cafeteria, auditorium and lecture rooms, library, and other common facilities.

Under a grant from the Educational Facilities Laboratory of the Ford Foundation, the campus architects developed a prototype laboratory building, plan and elevations of which are shown in the accompanying sketches. This basic building format is to be followed in each of the five campus laboratories. The building is modular, the basic module being geared to a 24 by 28 foot laboratory bay. The initial building consists of two two-story wings each of five such modules.

Design Philosophy

The over-all design plan is essentially a blend of the contemporary research park and the modern university campus. Fundamental research activity, represented by the work carried on in the central campus building complex, will be centered within peripheral areas of industrial applied research,





ADAPTABILITY

The structure of the typical laboratory unit will enable the distribution and alteration of services in any part of the building.

Vertical distribution is accommodated in a central service core (1) and in structural channels which form the exterior walls (2).

A channel flooring system provides for lateral distribution and permits access from both floor and ceiling (3).

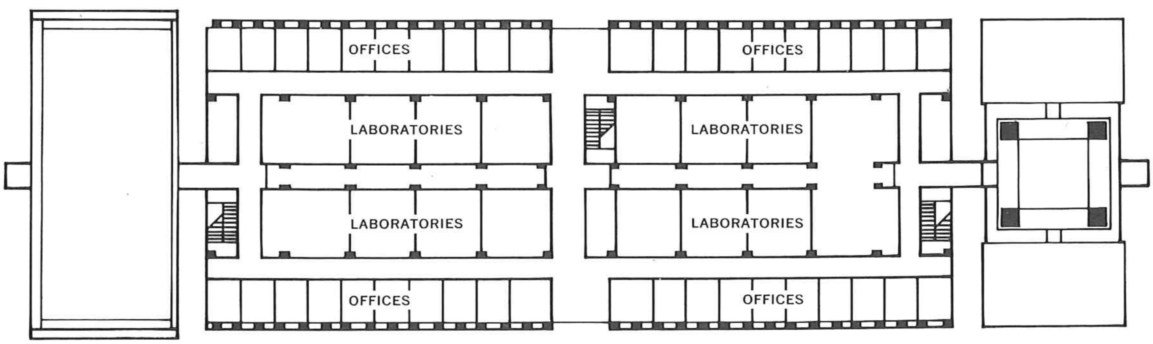
Extension of the service core above the roof provides space for additional mechanical equipment and the servicing of roof-deck installations (4).

Interior partitions may be arranged to suit any desired plan of laboratory and office space.

EXPANSION

Each research division is planned as a complex consisting of one or more basic laboratory units together with such special facilities as may be required. Those which cannot be accommodated in the basic laboratory units will be separately housed and linked at the ends of the laboratory units. The diagrams at right indicate a possible sequence of expansion.

1. Initial construction of typical basic laboratory units plus special facilities.
2. Expansion of basic laboratory space plus expansion or addition of special facilities.
3. Possible ultimate size consisting of approximately 120,000 square feet of basic laboratory space plus special facilities.



PLAN OF PROTOTYPE BUILDING

buffered by the remaining campus plots surrounding the central 70 acres. These campus areas will essentially comprise the Magnetic Facility, an expansive "front yard," and the botanical gardens on the South; and open campus plus a strip of related facilities on the east.

The north campus consists of a contingency area, properly shielded from neighboring activities and the central campus by topographical features. This region will provide locations for special facilities such as a possible particle accelerator, special antenna arrays, and experimental structures such as the neutron monitor facility (refer to Atmospheric and Space Sciences program section) which is currently under construction. This "back yard" space also will be adaptable to temporary or semi-permanent experimental usage involving the less pretentious structures often necessary to efficient research.

Within the central complex, it will be noted, the major laboratory structures and the central facilities building are tightly grouped. The intent of this arrangement is to encourage intimate daily association between the various groups. The use of connecting structures for lounge and coffee areas will create the architectural illusion of a large single building once one has entered any of the multiple structures.

By thus confining circulation to largely pedestrian traffic, the probability of "chance encounter" will automatically enhance communication between staff members — verbal communication, which affords quick exchange of ideas and often stimulates creative new concepts and approaches. This, combined with the inter-disciplinary nature of the scientific staffs, will aid materially in achieving the cross-fertilization of ideas so important to today's research.

Parking areas are arranged roughly as sectors penetrating into the building complex and so located as to allow for expansion both of building structures and related parking areas without distorting or compromising the functionality of this grouping. Vehicular circulation is confined to the peripheral road with tributary fingers penetrating into the building area at intervals and allowing for necessary delivery vehicles to serve the very center of the building group at subgrade level.

10- Finances

Graduate Research Center of the Southwest

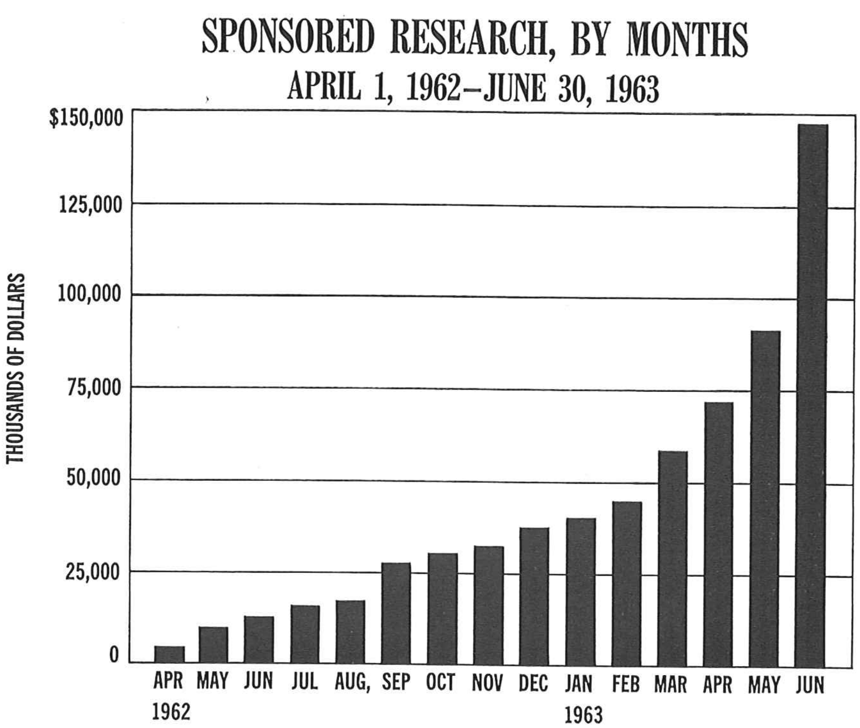
During the fiscal year ending June 30, 1963, the Center completed sponsored research projects totaling $615,835. The total staff at the end of the fiscal year was 100. This shows outstanding growth over the previous year when sponsored research was $28,059 with a staff of 19. The month-by-month growth in research volume from April 2, 1962, the date of the first sponsored research program, is illustrated in Chart I. Also during the year ending June 30, 1963, the Center spent $101,804 on its own research projects not paid for from grants or contracts from outside agencies.

Future Plans

Plans call for the eventual establishment of five principal laboratories under the Center's five-year plan.

Of the five, the Laboratory of Earth and Planetary Sciences is now in operation with 70 people on June 30, 1963; the planned complement as of June 30, 1968, is 270. The following three divisions

CHART I



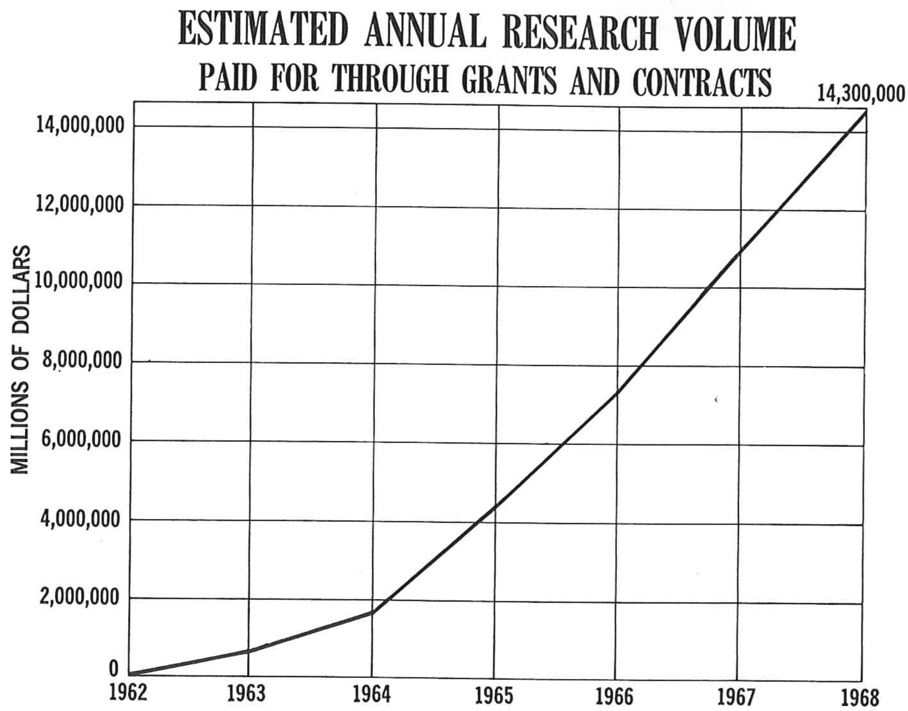


CHART II

of the four presently planned are partially staffed and working on research programs:

Atmospheric and Space Sciences
Geosciences
Mathematics and Mathematical Physics

The Computer Sciences Laboratory is now being organized and staffed. The other three laboratories are expected to begin operation at six-to-nine-month intervals. Over the next five years the staff is expected to reach nearly 1,000 with a breakdown somewhat as follows:

Earth and Planetary Sciences	270
Computer Sciences	60
Materials Research	115
Molecular Sciences	145
Electronics Sciences	100
Total Scientific and Technical Staff	690
Supporting Services, Administration, etc.	290
Total Staff	980

Such a staff, according to Center plans, will produce an annual research volume of $14,000,000 at June 30, 1968. The planned year-by-year growth is summarized below:

Fiscal Year Ending June 30	Est. Staff at June 30	Est. Annual Sponsored Research Volume
1964	247	$ 1,734,000
1965	544	4,656,000
1966	694	7,442,000
1967	845	11,139,000
1968	980	14,330,000

Chart II illustrates this projected financial growth.

Of the $1,995,000 research volume estimated for the coming year, $1,600,000 in signed contracts is in hand, the balance being made up of outstanding proposals whose acceptance is assured. This backlog of nearly one year's research contracts is an impressive accomplishments for a newly established organization. During the coming year the Center plans to spend $200,000 of its own money on research programs.

In support of the faculty and staff required to accomplish the research programs mentioned above the Center is developing the campus described in other sections of this report. Out of the planned expenditure for the campus construction and development totaling $20,600,000: $13,100,000 is for buildings; $3,800,000 for scientific and other equipment and $3,700,000 for land purchases. In addition to the above an investment of $4,400,000 is required for startup costs, unrecovered overhead costs, unsponsored research, interest, etc., from the date of the Center's inception through June 30, 1968. This total required investment of $25,000,000 over and above the amount involved in research programs paid for from outside sources has been obtained or will be sought as follows:

$ 5,000,000 from the Dallas Founding Fund Campaign

$20,000,000 to be raised through a national campaign and from matching U. S. Government sources.

The accounts of the Center were audited by the public accounting firm of Arthur Young and Company.

OPERATIONS

During the fiscal year ending June 30, 1963, operations resulted in a loss, with costs and expenses exceeding revenues by a small margin, as summarized below:

SUMMARY OF OPERATIONS

Year Ended June 30, 1963

Revenues:			
Research grants and contracts		$615,835	
Gifts		537,796	
Dividends, rent, etc.		10,684	
Total revenues			$1,164,315
Costs and expenses:			
Direct costs of sponsored research projects			
Salaries & Wages	$216,643		
Other direct costs	245,589		
		$462,232	
Costs of unsponsored research, recruiting and laboratory planning		226,234	
Administration and start-up costs		533,099	
Total costs and expenses			1,221,565
Net Income (loss)			($ 57,250)

FACILITIES

Construction was started in early June on the foundation for the first research building. This building is to be financed from proceeds from the Dallas Founding Fund.

Total investment in facilities at June 30, 1963, was:

Property, plant and equipment at cost:	
Land	$1,701,238
Equipment	86,736
Construction in progress (Research Building No. 1)	100,492
	$1,888,466

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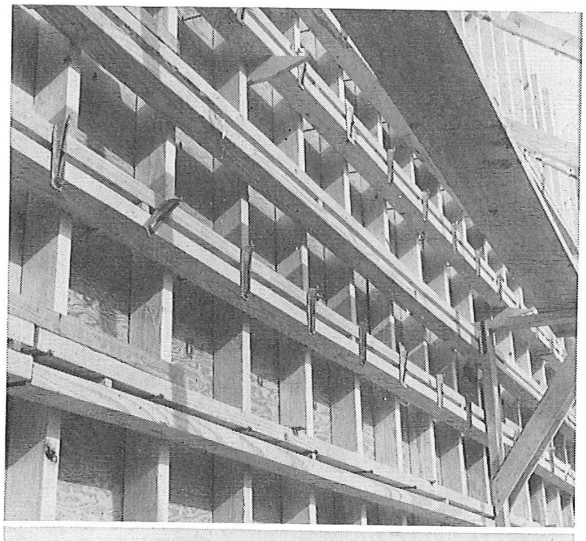
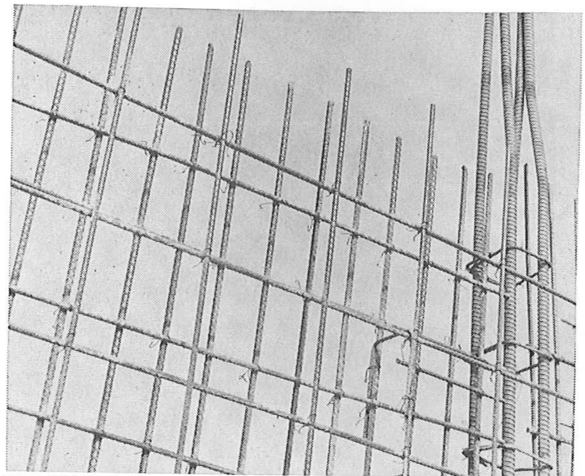
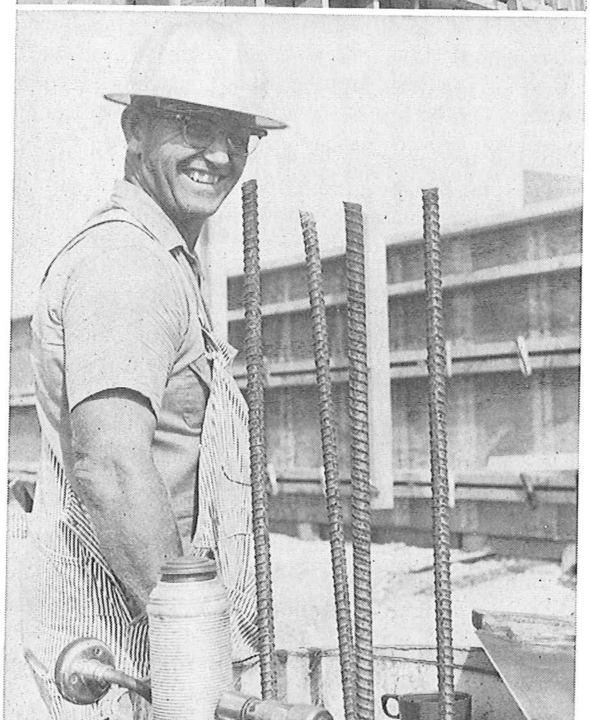
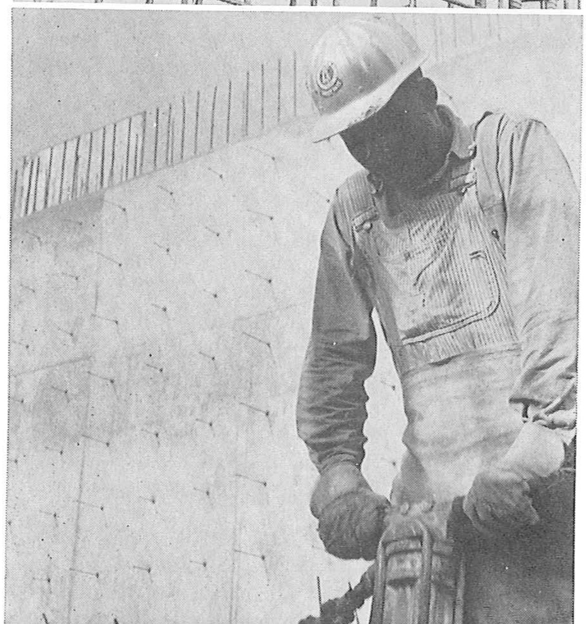
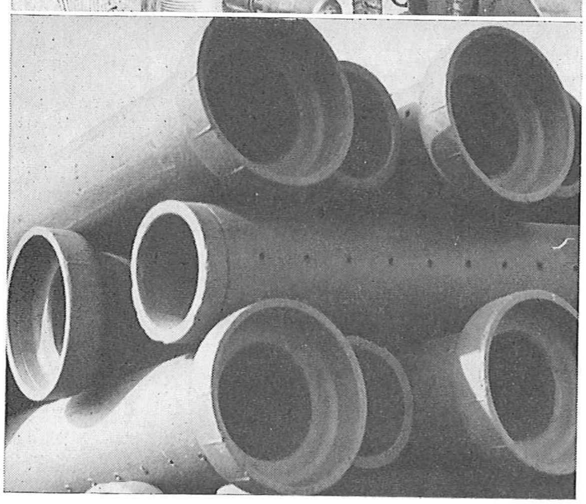
ON FACING PAGE — Men translate plans and materials into the reality of a research building on the SCAS campus.

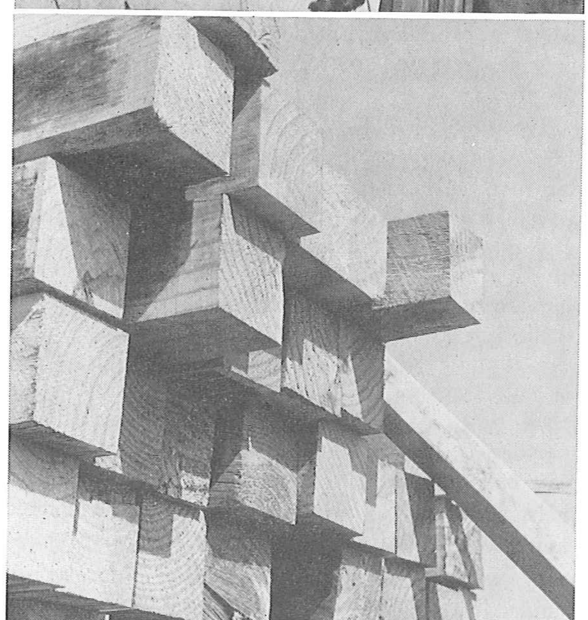












12- A Commentary

The Need for Quality

from Dedicatory Remarks of

Dr. Frederick E. Terman

Vice President and Provost, Stanford University

Member of the Board, Graduate Research Center of the Southwest

May 22, 1963

The feature of this enterprise that interests me most is that it is not limited to what is being done here in the Dallas area, important as this is. Rather, the grand plan, as I understand it, is to produce throughout the Southwest a public understanding of the importance of scientific research in the development of industry, and to create a climate of public interest and support that will aid in building scientific strength in the entire Southwest, including particularly *all* of the educational institutions of the area. This is important because no one organization, no one school, or no one city, can alone do all that needs to be done.

Success — real success — in the broad undertaking will be measured in terms of the quality of what is produced in the way of research competence, research performed, and trained young people.

The flow of dollars into a research activity is far less important than what is done with the dollars available. In these days, any organization or educational institution with energetic management and good area backing can collect large numbers of dollars for so-called research if it has a pool of technically trained manpower available. This is particularly easy for a non-profit or educational institution that is attempting to serve a noble purpose, as is the case here. If the organization is really first-class, with able leadership and solid rank and file personnel, government funds in adequate amount can be obtained on merit through the usual channels, and political pressure and the "pork barrel" approach are unnecessary. If such tactics are necessary to keep the enterprise going, then it isn't doing the job that it should, and something in addition to dollars is badly needed. To repeat, the success of the program will be measured not in terms of the dollars that flow through it, but rather upon the quality of the people who will be spending the dollars.

Again, the acquisition of expensive equipment is far less important than what is being done with the equipment. This is because the equipment expenditures measure only the success in raising money — any unimaginative fellow with dollars in hand can spend money for particle accelerators, big nuclear reactors, big radar antennas, mass spectographs, etc., even if he doesn't have a single first-class idea for the use of such equipment.

Similarly, the number of new Ph.D. programs that educational institutions in the Southwest are able to announce is of no great significance. Such announcements merely represent administrative action which may be wise or unwise, justified or unjustified. What counts in education is quality — quality of faculty who lead the research and provide the advanced training, and the quality of the students being trained. Ph.D. programs are meaningful only when evaluated in such terms rather than by totting up catalog announcements.

Finally, and for the same reasons, the number of students enrolled in Ph.D. programs and the number of Ph.D. degrees awarded per year mean very little until this output is evaluated in terms of the quality of the students involved, and the quality of the training available to them.

Translated into positive terms, what I'm trying to say is that success of the program, both here at the Graduate Research Center of the Southwest and in educational institutions all over the Southwest, will depend upon the people involved — the caliber of the scientific leadership provided by the staffs and faculties involved, and the caliber of the pre- and post-doctoral students going through various parts of the system. The real product is trained people — buildings, equipment, and research dollars are only a very indirect and highly unreliable way of measuring the real results.

Research dollars properly spent in educational institutions and non-profit institutions have a great leverage factor on the communities they serve, and the dollars involved then have high productivity. However, if excellence is lacking, this leverage disappears and the dollars become sterile. This means that it is important to aim high, and not compromise with quality in order to make a quick showing. It means that self discipline must be employed to limit oneself to what can be done well, and not to undertake just any activity merely because funds can be obtained for it.

At Stanford our success has been in large measure the result of concentrating on a limited number of areas in the main stream of importance and then doing them well. Stating it another way, we have concentrated our resources on the building of a few steeples of excellence, rather than in trying to do fairly well in many things.

When an institution is playing the game for quality it should do so whole-heartedly. In faculty development this can be illustrated by the following example. Assume that $60,000 in salary money is available for developing a strong department. The typical academic approach would be to establish five positions at about $12,000 each. However, if one really wants quality, a better way to go about this is first to go out and get a $20,000 man. After he has been signed up, then one would use him to locate and recruit four more men at $10,000 each to work in co-operation with him. Note that the total cost is still $60,000. However, if the $20,000 man is really the kind that he should be, the $10,000 men recruited with his help and his prestige will be as good and maybe even better than the $12,000 men that one would recruit under the other system that does not provide top leadership around which to build.

The same type of thinking and approach would apply to non-profit organizations such as the Graduate Research Center of the Southwest, although the dollars per person may be in a different pattern.

The game of quality also applies to graduate students as well as to faculty. It is better for a good man on the faculty to have two or three really first-class graduate students working with him than to have six or eight, all of dubious quality. This has implications as to the student aid policies; it means better paying research assistantships and fellowships, but fewer of them.

Now, for everyone involved in the great undertaking of raising the scientific horizons in the Southwest, and this includes the non-academic as well as the academic groups, my advice is to be patient. It has been said that Rome was not built in a day, and it should be noted that the science-oriented centers of strength in California, New England, etc., that you wish to rival were not built in five years or even a decade. Accordingly, don't expect too much too soon. It is better to build soundly even though this means proceeding with some deliberateness, than uncritically to develop the largest possible program in the shortest possible time. Scientific research and graduate level education in science and engineering are highly competitive activities. There is competition with already well established centers of strength, and with new centers that are in the process of development, such as your own. Success that is lasting will, as I have said, be measured in terms of the excellence of the work performed, and the quality of the staff, faculty, and students involved, rather than by the dollars, the equipment or the buildings.

After offering you this free counsel and guidance, let me conclude by saying that you have here a crusade that is worth supporting, both from the point of view of the selfish interests of the Southwest, and from the point of view of the contribution that can be made to the nation. The results you want won't come either as easy or as fast as you would like, but I can see no obstacle that hard work, persistence, and patience will not overcome. I wish you success in this undertaking and believe that you will have it!

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