Edited In Retrospect

OR at Tech

• Two days after the radioisotopes symposium was held here (see pages 10-12, this issue), some 900 members of the American Institute of Industrial Engineers arrived at Atlanta's Biltmore Hotel for their tenth annual conference. Georgia Tech was well represented in the list of attendees, committee chairmen, and speakers. Notable for its contribution to advanced thinking in modern industrial engineering was a paper by Dr. Ernst Swanson, senior research economist in the Industrial Development Branch of the Engineering Experiment Station. The paper concerns the economics of product diversification and a quantitative method of evaluating the alternatives.

Dr. Swanson's paper falls into the realm of operations research, a subject generally enveloping a number of quantitative tools and their use in aiding management decision-making. Various Georgia Tech researchers have done interesting work in this new field, and the expanding graduate and research programs in the School of Industrial Engineering are resulting in further operations research activity at the institution. We are planning to report some of this work to the readers of this magazine in the near future. In particular, we are looking forward to an article on a project presently underway at the IE School. Dr. Harold Smalley is directing research sponsored by the National Science Foundation on the economics of disposable versus reusable hospital supplies. The work has just begun, and we hope to present some results in the December or February issue.

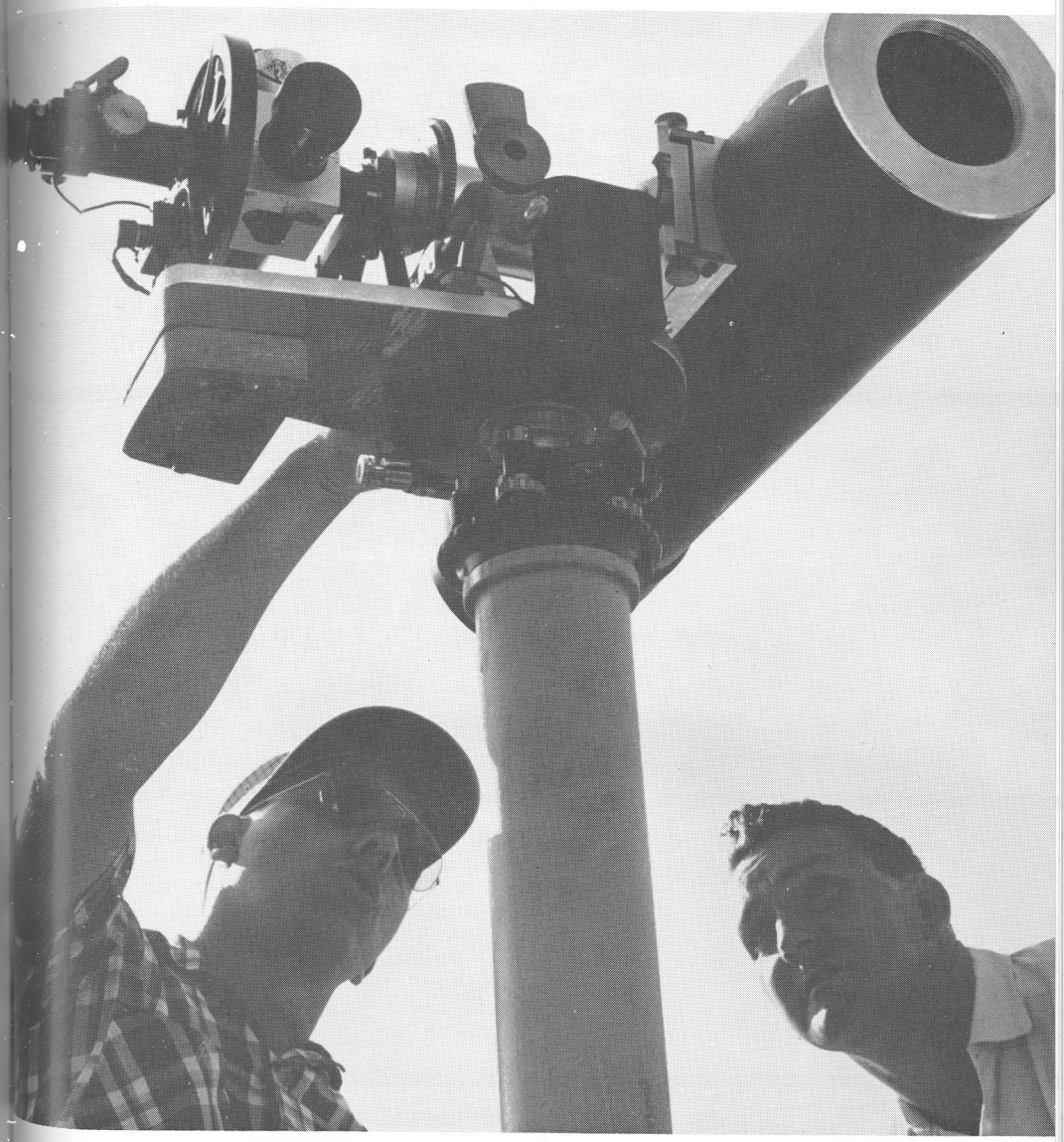
Tic-tac-terror

• An error of omission occurred in this column in February. We discovered after publication that Dean Ralph Hefner's successful proxy battle with the electronic computer was not over an ordinary game of tic-tac-toe. Rather it was a three-dimensional version and had 16 squares on a side instead of the usual 9. Thus it was possible to score in dozens of ways, with rows through the cube as well as on the side. Mrs. Bess Scott, who served as the Dean's second at the Computer Center, tells us that a game of this complexity is no idle pastime.

OCTOBER, 1959

The Research Engineer

Published by the Georgia Tech Engineering Experiment Station



New Fields of Study

Special Research Report

The Research Engineer

VOLUME 14, NO. 4 OCTOBER, 1959

Published five times a year by the Engineering Experiment Station
Georgia Institute of Technology, Atlanta, Georgia

contents

the cover

The instrument shown in the cover photograph is a combination theodolite and spectroscope, one of the many devices used in the study of the physics of the upper atmosphere. Georgia Tech research physicist John Brown (left) explains the operation of the instrument to a visiting Canadian scientist during Project Firefly, a series of experiments using rockets to release chemicals high in the atmosphere. Research in this field is one of the new programs begun at Georgia Tech during 1958-59. More information on Project Firefly is planned for this magazine in the near future.

Cover photo by Cecil Phillips. Others in this issue as noted.

THE RESEARCH ENGINEER is published five times a year in February, April, June, October and December by the Engineering Experiment Station, Georgia Institute of Technology. Second-class postage paid at Atlanta, Georgia.

The President's Page

OIL MEN say that they must continually search for new reserves, even though existing wells can produce more than enough for the present demand. Spurring this great annual investment in exploration is the fact that in just eleven years (1948-1959) oil consumption in the U. S. has jumped 50 per cent. In the face of such accelerating demand, even the enormous known reserves may become inadequate surprisingly early.

For the same reason, the continuing expansion of our reserves of knowledge is an absolute necessity to meet the voracious appetite of modern technology. Rapid advances in all directions are bringing more and more interest in both basic and applied research. Industrial firms, government agencies and other establishments are increasing their research investments just to keep up the pace in their respective fields.

It is to the growing credit of America's instiutions of higher learning that their research programs are not merely keeping up the pace. As the report in this magazine brings out, Georgia Tech researchers are anticipating the questions and problems of tomorrow and are working toward these answers today. This is especially evident in the recent expansion of our basic research programs. Many of the new areas of study were almost unheard of a decade ago. In the next decades they may hold the key to America's prosperity—or survival.

On earth there is only a finite amount of real estate, on land or under the seas. If the search for oil continues long enough, prospectors will eventually find the last oil field. But the fields of knowledge are limitless. The mastery of one leads inevitably to another, and the reserve of knowledge continues as mankind's greatest resource.

E. D. Harrison

President

The First Quarter-Century

IN THE YEAR 1934 it was still generally believed that rayon had to be made from high-grade wood pulp; Georgia's clay deposits were being used almost exclusively by a few brick and tile manufacturers; and there still seemed to be a future for autogiros, in spite of some new developments in the powered-rotor aircraft called helicopters.

And in 1934, Georgia Tech's Engineering Experiment Station began its first year of operation. Among the earliest research projects were studies of viscose rayon and its production from southern pine—now the principal raw material in the rayon process. Ceramics research, which began in 1934, has resulted in a number of new industries for the State based on a variety of products, from whitewares to missile nose cones. Research in helicopter engineering, which began in 1935, has contributed significantly to the present state of the art. Aeronautical projects, particularly helicopter studies, still form a major research program at Georgia Tech.

Similarly, throughout the Engineering Experiment Station's 25-year history, research in engineering and science has shown results. Progress has been especially apparent in the fields directly related to Georgia's industrial growth. But the benefits of research have not been confined to economics. The presence of important research activities has been of great value to the faculty and the educational programs of the Institute. Investigations in basic science have helped push back the frontiers of knowledge. And, since the beginning of the radar projects eleven years ago, Georgia Tech's contributions to the nation's defense have been substantial.

The continuous and successful growth of the Station's research activities is due in a large measure to the original statement of its goals. The Engineering Experiment Station of the Georgia Institute of Technology was authorized by the 1919 General Assembly of the State of Georgia. In the words of the Enabling Act, the Station was established for ". . . the promotion of engineering and industrial research . . . the more complete development and utilization of the resources of Georgia . . . the encouragement of industry and commerce . . . and for insuring the public welfare of the people consistent with modern progress and preparedness."

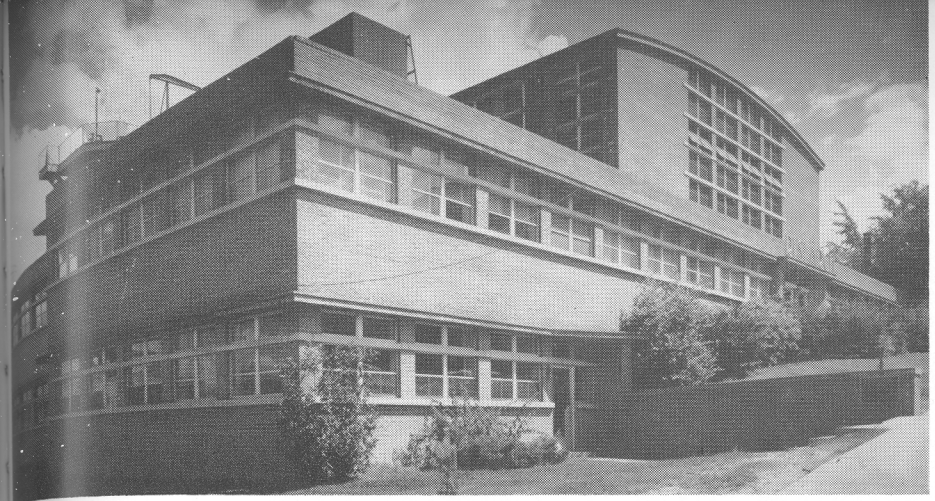
In 1919 there were very few engineering experiment stations in the nation. Not many members of that General Assembly could have had any experience with the administration and operation of an engineering research organization. Yet the principles of the Enabling Act have provided a sound and valid foundation for the Station's research plans ever since 1934, when actual operations began.

The achievements of the Station during its first quarter-century have been numerous and gratifying. New knowledge of atoms, molecules and crystals has added to understanding of the basic structure of matter and its binding forces. New techniques for the study of cells, bacteria and airborne particles have led to information needed for better health practices. New paints for Georgia pines, new processes for naval stores materials, and an important new ceramic material have aided in the development of Georgia's resources. The continued production of skilled and experienced research scientists and engineers has been important to the South's technological advancement.

Recent years have witnessed a sharp acceleration in the Station's rate of growth. Much of the expansion has been in new fields, especially in the basic sciences. Recently initiated programs, such as plasma physics, neutrino detection, industrial uses of radioisotopes, and small-business economics are broadening the Station's fundamental capabilities and increasing its capacity for service.

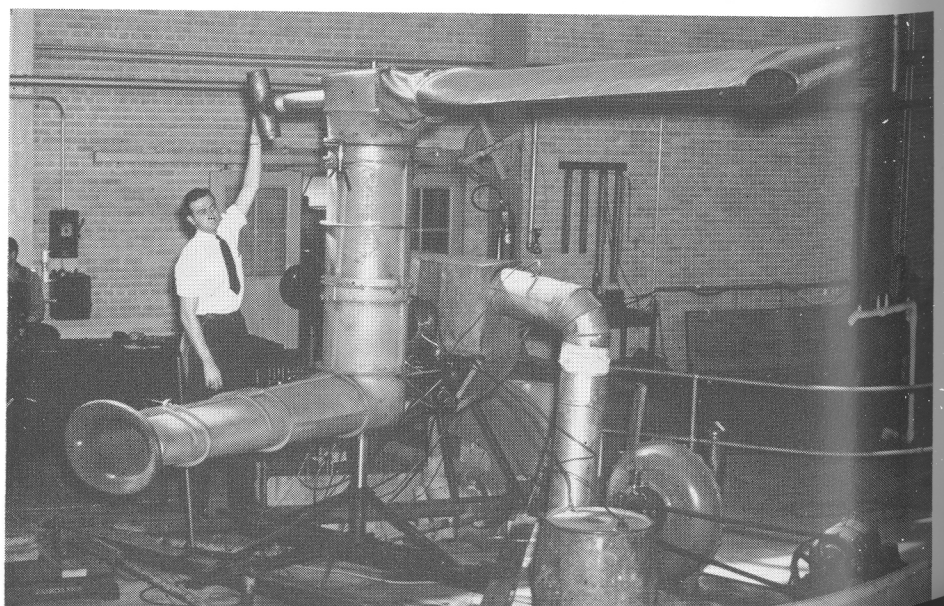
Early entry into the young science of high-speed computation in 1955 brought general support to almost all research on the campus, often facilitating studies that otherwise would have been impossible to undertake.

Future plans call for further advances. Ground will soon be broken for the first large-scale research reactor at a southern university. Other facilities and programs are being developed in radiochemistry, the solid state sciences, natural resources, the atmospheric sciences, the health sciences, and other areas of particular interest to Georgia Tech, industry, the State, and national defense.

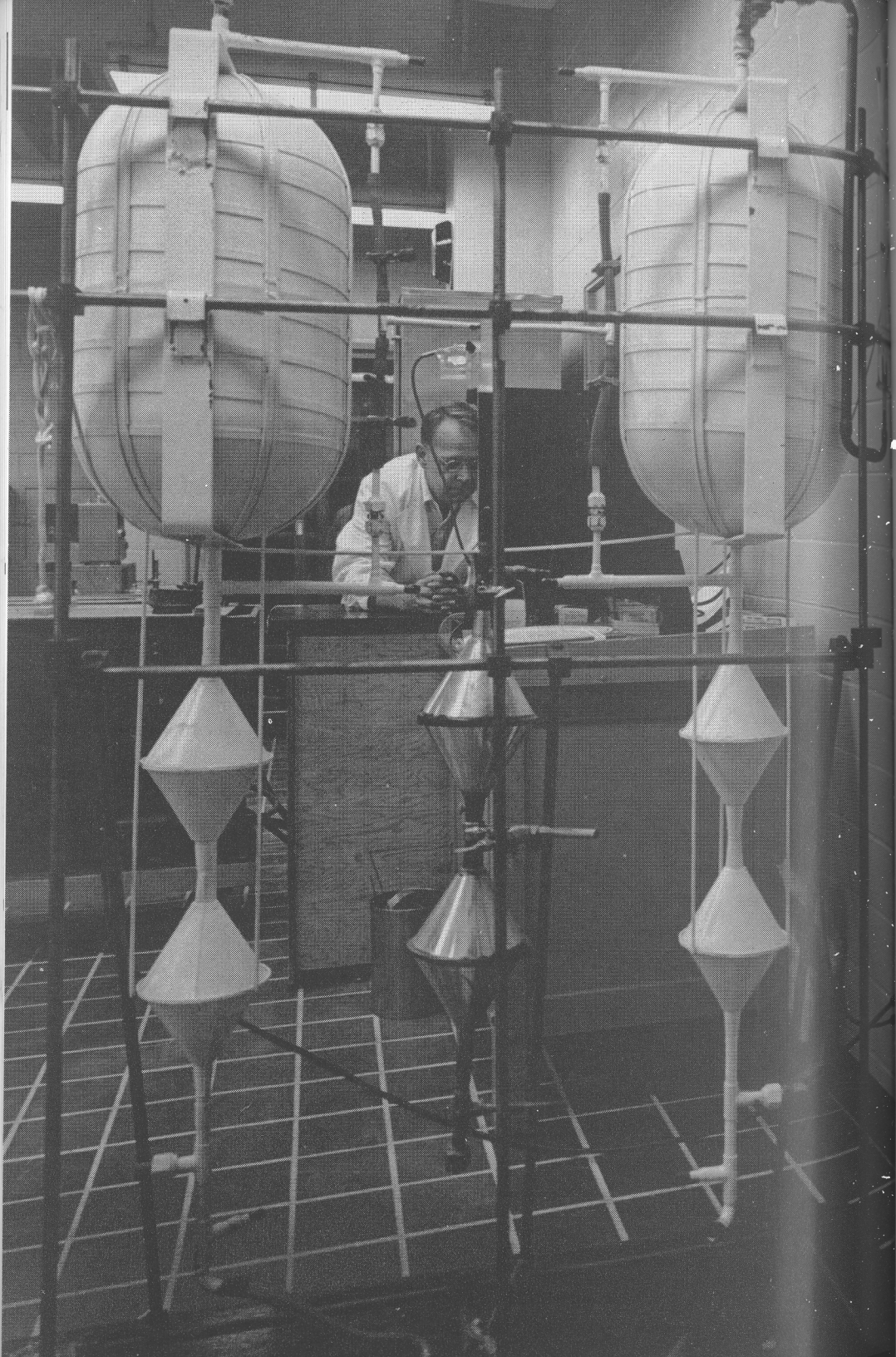


Harlee Furgeson

HINMAN RESEARCH BULDING WAS BUILT IN 1939, WING ADDED IN 1951.



Probably world's first jet-powered helicopter experiment is shown in this 1943 photo in the Station's shop area. Helicopter studies began at Tech in 1935.



The Finest Year: 1958-59

by James E. Boyd, Director
Georgia Tech Engineering Experiment Station

In 1959 the Engineering Experiment Station completed its first quarter-century of operation. And, fittingly, the twenty-fifth year was the best all-around year in the history of research at Georgia Tech. By all measures, the value of services to the Institute, the State, industry and the nation during this year reached new highs.

The Station's capabilities for research in both the fundamental and applied sciences were improved significantly by the addition of highly qualified professional people. Although several important men were lost, the addition of other outstanding researchers resulted in a net gain for the year. The new staff members have strengthened established research programs and have made possible new programs of great interest. In particular, the Station's activities in physics, industrial development, and electrical engineering have benefited by the experience of the new personnel.

Perhaps the most outstanding single development in the Station's 25th year was the completion of the Radioisotopes and Bioengineering Laboratory. This building is considered one of the finest of its kind in the world. At a cost of approximately $500,000, the building provides 16,000 square feet of air-conditioned and specially designed laboratories (*Research Engineer,* February, 1959).

The facilities of the Rich Electronic Computer Center essentially doubled during the year. The Burroughs 220, a large-scale, high-speed computer, was installed and put into operation. The input-output flexibility, the large auxiliary tape memory system, and other characteristics of the 220 supplement the capabilities of the UNIVAC SCIENTIFIC (ERA 1101) and the IBM 650. With these three computers and associated equipment, Georgia Tech has a computer center as versatile as that of any other university in the nation.

Other major improvements in Station facilities included modification of the UNIVAC by adding a 4,096-word magnetic core memory, enlargement of the AC Network Calculator, and construction of a 960-square-foot Butler building for the slip-casting operations of the Ceramics Branch.

Georgia Tech's Research Reactor Project received a $750,000 grant from the National Science Foundation. This grant, together with the $2,500,000 and accumulated interest already on hand, assured that construction on the project could begin. It is expected that ground will be broken by early 1960.

The Station's accrued income reached a record high of $2,958,000, a 24 per cent increase over the previous year. Of this amount, $470,000 was furnished by the State of Georgia through the Board of Regents. The remaining $2,488,000 came from government, industry, foundations, endowment income, and through direct services to Georgia Tech.

The total of 342 projects active during 1958-59 represents a record increase

← *Bill Diehl*

These aerosol cylinders are used in studies of airborne bacteria and disinfectants.

Harlee Furgeson

NEWEST RESEARCH FACILITY IS ONE OF WORLD'S FINEST OF ITS KIND.

of 72 projects over the previous year. Primary factors contributing to the increase were: (1) the increased appropriation from the Board of Regents, which made possible a higher number of State-supported projects; (2) a larger number of industrial projects, especially in the Computer Center and the Industrial Development Branch; and (3) a great increase in the number of basic research projects sponsored by federal and state agencies and independent foundations.

Georgia Tech Research Institute

The Georgia Tech Research Institute, a non-profit Georgia corporation closely integrated with the Engineering Experiment Station, continued to serve as the Station's contracting agency. In this capacity the Research Institute negotiated 114 new research contracts for Georgia Tech during the year.

In its legal and financial functions the Research Institute also aided the Station's programs by administering patent activities, coordinating outside interest and support, and making available funds for the furtherance of research on the campus. During the year these efforts resulted in three new patents for staff members; the modernization of the AC Network Calculator, through support from the Southern Company group of utilities; and the procurement of the Burroughs 220 Computer, made possible by the support of the Rich Foundation.

Services to Georgia Tech

The Station's 25th year was its largest in terms of services to the faculty and students of Georgia Tech.

Through direct participation in research projects, a record number of 111 faculty members increased their knowledge of their specific fields. Eighty graduate students and 140 undergraduate students (also record numbers) gained valuable research experience and needed financial help through employment by the Station during the year. Many graduate theses were made possible through work on Station projects or facilitated by the use of computers or other equipment. The X-Ray Diffraction Laboratory alone was used by 14 graduate students to work out problems related to their theses. In addition, Station staff members acted as advisors on theses of other graduate students.

Several special lectures and seminars for faculty, staff members and students were conducted by Station personnel during the year. The Computer Center, for example, conducted a series of seminars each quarter on the use of digital computers.

Specialized equipment was made available by many of the Station's divisions for the use of various schools and departments of the Institute. The Computer Center was used for laboratory purposes by classes in 11 different departments and by faculty members in three other departments. The Analog Computer Laboratory, the X-Ray Diffraction Laboratory and other areas were also used for instructional purposes.

Services to the Nation

Sponsored research is an integral part of the educational system at Georgia Tech. Whether in the departmental laboratories or in the centralized research facilities of the Station, sponsored research projects provide unusual opportunities for both students and faculty to participate in research at the frontiers of their fields.

It is also true that urgent demands will be made upon Georgia Tech's resources in times, such as the present, when the safety and the strength of the free world depend so greatly on a high level of science and technology. Such responsibilities are accepted on a selective basis, when the work is in fields in which the Station has particular competence and which will benefit the educational mission of Georgia Tech. During 1958-59 the Station continued its active programs for the military services and other Government agencies, and several new projects were initiated.

Services to the State

Research for agencies of the State of Georgia and local governments increased both in volume and in significance during 1958-59.

Several projects were undertaken for the State Highway Department (together with the U. S. Bureau of Public Roads) to find ways of improving the quality of roads and to reduce the costs of construction. These investigations involved new types of pavements, improvements in pavements using Georgia materials, and other studies important to the development of modern highway systems.

The Georgia Department of Commerce, the Columbus Chamber of Commerce, the City of Brunswick, the Georgia Ports Authority, and the Flint River Development Committee are among the agencies that were served by the Industrial Development Branch. The research of this recent addition to the Station has grown to major proportions and has already been of evident value in bringing in new industry, evaluating markets and resources, and otherwise aiding the development of the State's industrial potential. New, long-range contracts received during the year ensure that the Branch will continue to play a growing role in Georgia's economy.

Services to Industry

During the year the Station offered strong research support to industry and business in Georgia and the South. For the sixth consecutive year over one-half of the industrial projects were carried out for Georgia firms.

One of the most interesting new programs of industrial service initiated by the Station will help Southern manufacturers benefit from the latest developments in atomic energy. With the support of the Atomic Energy Commission, the Chemical Sciences Division and the Industrial Development Branch will study the applications of radioisotopes in production processes. The program began in May with the Symposium on the Industrial Uses of Radioisotopes, a successful meeting of 175 industrial representatives.

The varied programs of the Industrial Development Branch also included projects of direct assistance to industrial firms and groups of firms. The Branch provided such information as labor resources, opportunities for diversification, and data on other questions best suited to research at the university level.

Bill Diehl

Powerful, accurate, universal testing machines measure the strength of materials.

Technical Operations

EACH MEMBER of the Engineering Experiment Station's staff is assigned to one of its technical divisions or branches or to one of the service groups which provide the auxiliary functions necessary to a modern research organization. Projects are assigned to the division or branch in which the major portion of the work will be conducted, while the other units render assistance as required. Under this system, now in its ninth year at Georgia Tech, administration and supervision of each project are centralized, and the facilities and full capabilities of the Station are available for use in the prosecution of all projects.

Chemical Sciences Division

THE MOST SIGNIFICANT DEVELOPMENT of the year in the program of the Chemical Sciences Division was the expansion of the use of radioisotopes in research related to industrial problems. Key contract in this expansion was the large one awarded by the Atomic Energy Commission for a radioisotopes development program at Georgia Tech. The program will be concerned with the industrial uses of radioisotopes, with particular emphasis on the industries important in the South.

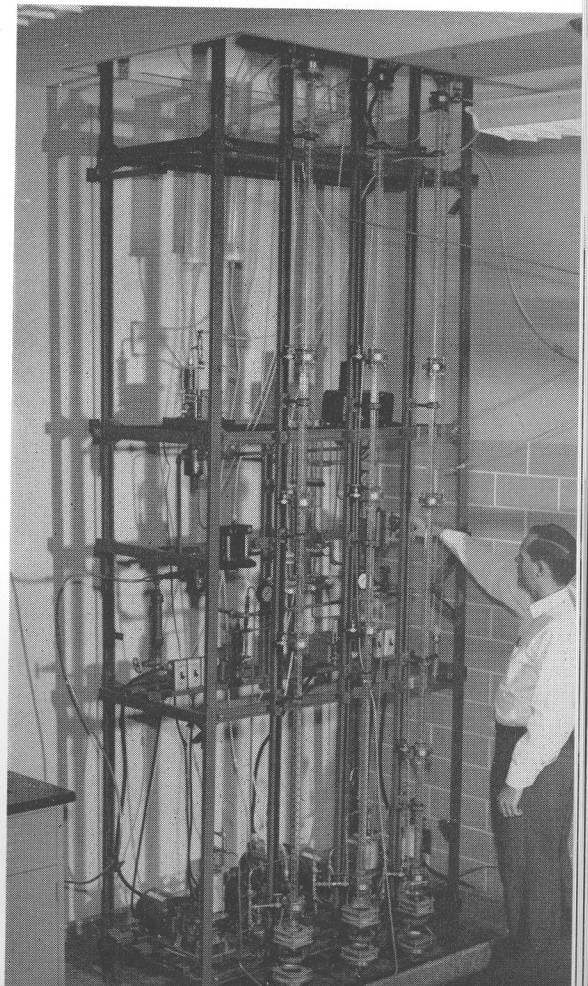
Several specific research tasks under the AEC contract have been authorized and are well underway. These include the construction and installation of a 12,000-curie cesium-137 irradiator, which will be used in high-energy radiation studies.

The highly successful Symposium on the Industrial Uses of Radioisotopes, which was held at Georgia Tech in May, was also a part of the program sponsored by the AEC. The two-day symposium was attended by 175 representatives of industrial firms from 21 states and two foreign countries (*Research Engineer,* June, 1959). Two dozen scientific papers were presented on applications of isotopes in paper mills, textiles, foods, general manufacturing, and on the fundamentals of isotope use.

Other fields of chemical research represented in the Division's activities during the year included adhesives, air pollution, bacteriology, bioengineering, catalysis, chemistry of photoengraving, concrete products, corrosion, fine particles, industrial wastes, meteorology, naval stores chemistry, physical organic chemistry, photochemistry, radiation chemistry, surfactants, textile chemistry, textile fibers and water quality.

Georgia Tech's Micromeritics Laboratory continued to contribute to the knowledge of vapors, smoke, dust, and other fine particles in the air. One project in this field concerns the adhesion between airborne solids and solid surfaces. In this study, the tenacity with

Harlee Furgeson



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The photoengraving (of solvent extraction columns) at right was etched on copper by Georgia Tech's successful powderless etching process, which was improved in 1958-59.

which dust and smoke particles adhere to painted surfaces, brick walls, and even the leaves of vegetation has been measured.

The purpose of the study is to establish the feasibility of making contaminating or toxic particles airborne again once they have settled out of the air. As expected, considerable variation has been found for different combinations of particles and surfaces, but inevitably adhesion increases as the air's humidity rises. Even under normal conditions the adherence is surprisingly great; a wind of 55 mph would be required to dislodge a typical dust particle of 25 microns diameter from a plant leaf, for example. Speed as a means for blowing off any significant quantity of the dust that settles on an automobile is revealed as completely impractical, since speeds of at least 490 mph are required.

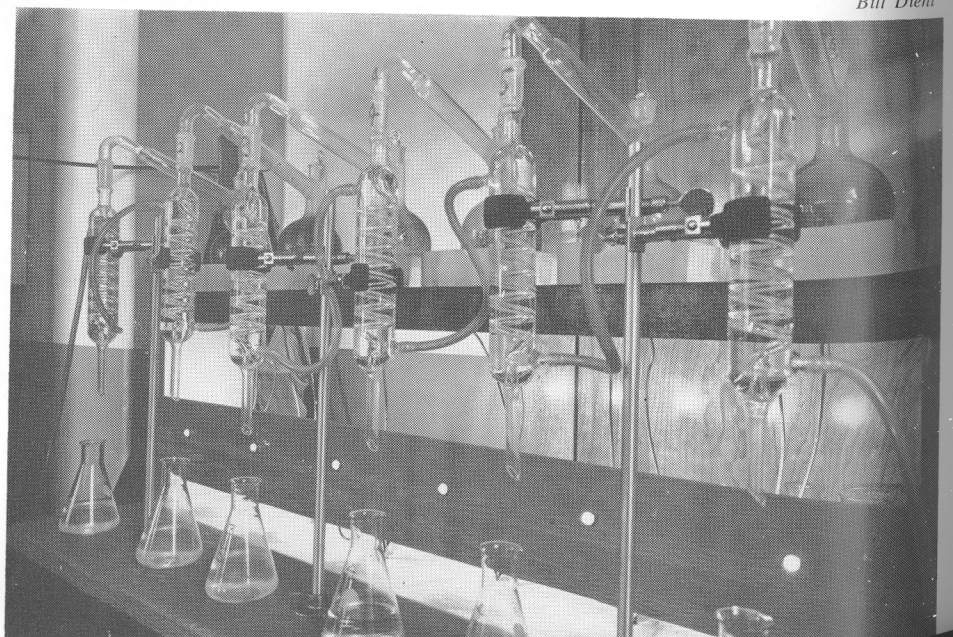
Research on airborne bacteria is representative of Georgia Tech's activity in the field of bioengineering. In one study, the effects of temperature and humidity on airborne bacteria are being measured. During the year the survival of airborne bacteria was studied as it depends on temperature, water concentration, and rates of water uptake and loss. The current studies have been concerned with the question of the maximum lethality of a critical moisture content. The results are applicable to basic cellular physiology as well as to the survival of airborne bacteria.

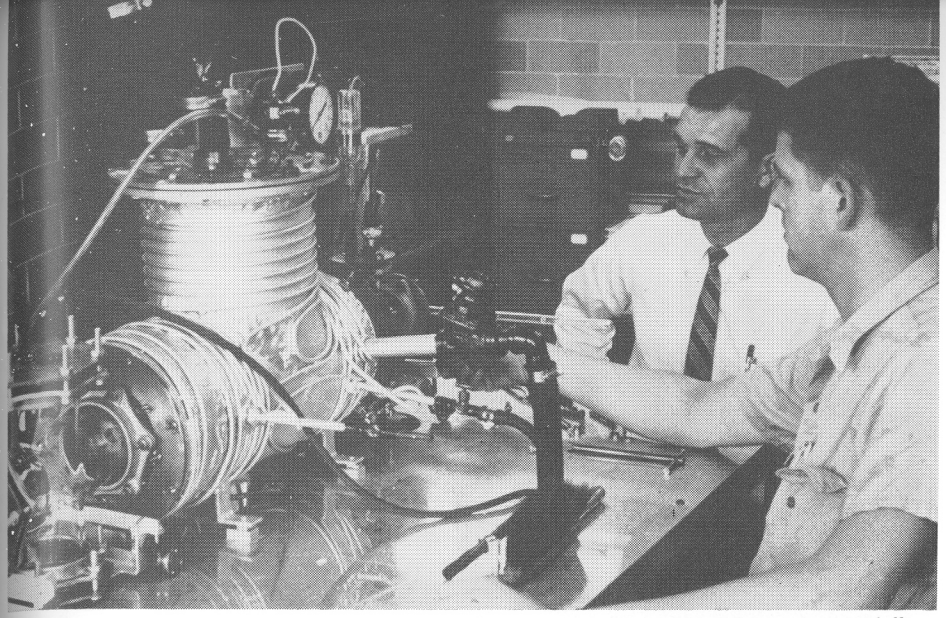
In the area of sanitary engineering, one of the more significant research projects completed during the year dealt with river waters in Georgia. In this study, which was supported by State funds, a major portion of the effort was devoted to studies of the Chattahoochee River below Buford Dam.

Many chemical and physical changes take place in the water above a power dam, due to the quiescence of the lake, the level at which the water is discharged, and other factors. These changes show up in the stream below the dam. The results of this research have been of interest to several state and federal agencies concerned with water resources, including the United States Army Engineers and the Georgia State Game and Fish Commission.

During the year the Industrial Products Branch solved a variety of chemical problems for commercial and government sponsors. One of the most successful studies resulted in a thread-sealing and antiseize compound for use in oxygen systems of aircraft, where very high temperatures and oxygen pressures are encountered. The compound that was developed is operative up to 550°F, and in certain applications, up to 600°F.

Bill Diehl





Phillips

RESEARCHERS BUILT SPECIAL-PURPOSE FURNACE FOR CERAMICS PROJECT.

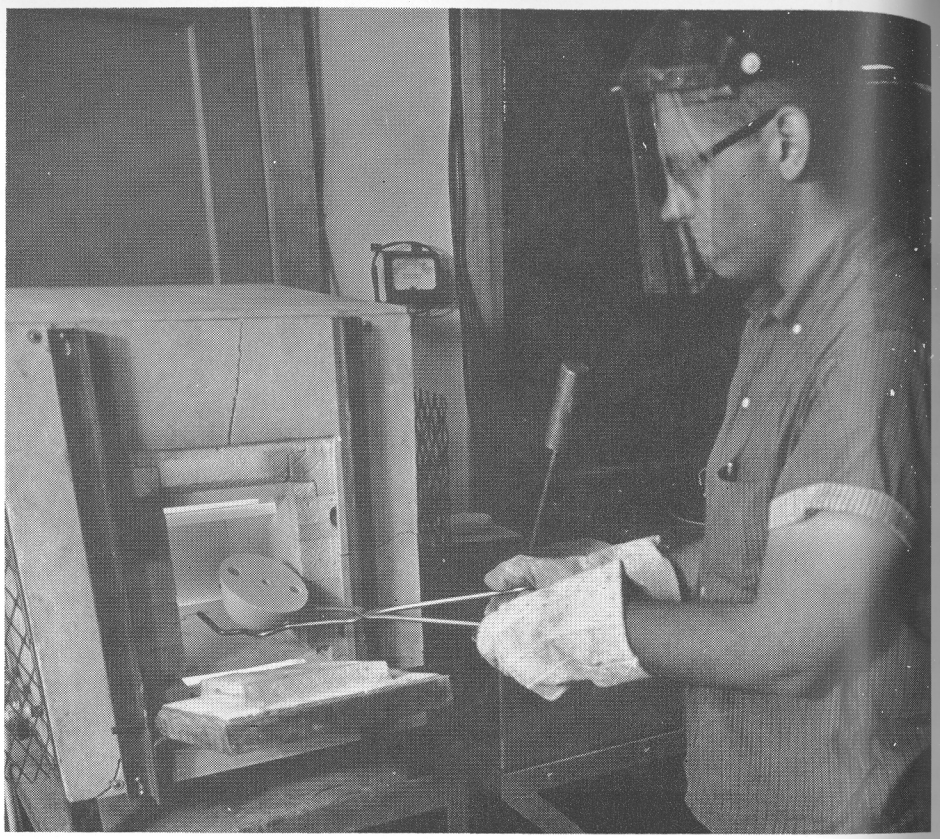
Material Sciences Division

THE WORK of this Division's Ceramics Branch attracted even more national attention than in previous years as new applications for fused silica were developed and studied. New projects were initiated to apply fused silica to the problems of nuclear ceramics, ceramic tooling for the aircraft industry, and the fabrication of astronomical telescope reflectors.

The commercial firm that first sponsored much of the work on fused silica continued to grow, and prospects for a hundred-million-dollar industry based on applications of the fused silica process were announced by the firm's officers.

The industrial use of fused silica has expanded to include fixtures for honeycomb brazing of stainless steel structures for high speed aircraft. Massive pieces over ten feet in length have been easily fabricated. Other applications include refractories for pouring and containing molten metal as well as general refractory uses. A technique was developed whereby a foam refractory can be produced from the finely divided silica. These highly porous bodies are light and have extremely low thermal conductivity, good thermal shock resistance and good physical properties. The foamed fused silica can be used as an insulation material or as a refractory to temperatures above 2500°F.

The much-publicized work on the nose cones of ballistic missiles also continued. Techniques for slip casting large nose cones from fused silica slip were devel-



Bill Diehl

SAMPLE OF SLIP-CAST FUSED SILICA IS TAKEN FROM KILN FOR TEST.

oped, and one of the resulting nose cones was successfully tested at Redstone Arsenal on one of their burner test stands. New and promising compositions for re-entry vehicles were investigated.

A project devoted to the basic understanding of slip-cast fused silica as it relates to certain applications in nuclear reactor engineering progressed through several important phases during the year. Studies of the kinetics and mechanism of particle bonding and crystallization of various forms of silica were made, using electron microscopy, high temperature x-ray diffraction, surface area determinations and physical property measurements. Various methods of sealing the porous silica to decrease its permeability to gases were evaluated. Fabrication studies involved the slip casting of single-piece, simple shell and tube silica heat exchangers. Also, preparations were made for an in-pile investigation of radiation damage in fused silica.

Another example of fundamental research in materials sciences is the current study on the mechanism and activation energy for diffusion through single-crystal and polycrystalline high temperature materials. Diffusion of inert gases through two metallic oxides (UO_2 and Al_2O_3) will give information concerning diffusion as a function of exposed area, uncomplicated by chemical influences. Ultimately this knowledge is expected to have direct bearing on the materials used in reactor fuel-element packages, which require certain diffusivity qualities.

Mechanical Sciences Division

BOTH OLD AND NEW programs in the Mechanical Sciences Division obtained significant results during 1958-59.

One of the most satisfying projects of the year was a hydraulic model study of the spillways of a proposed dam in Iran. The 630-foot dam, one of the world's highest, is designed to control the vital water supply of the Dez River.

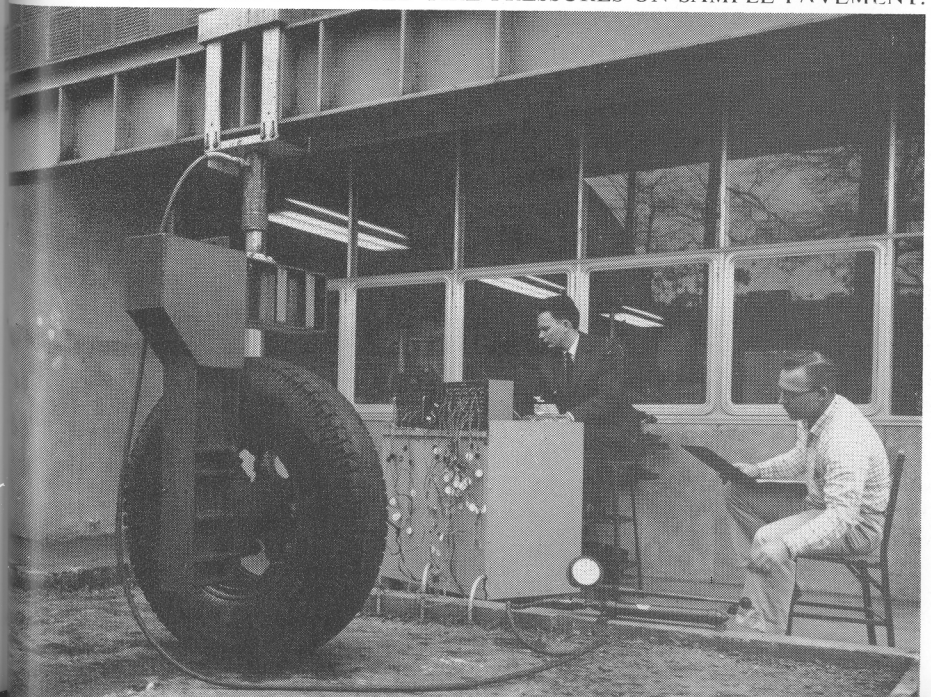
The dam's particular location in a deep gorge and the potentially large flood conditions in the region caused the spillway tunels to have several unique features, which were studied by means of a scale model of the system built in the Hydraulics laboratory of the School of Civil Engineering (*Research Engineer*, April, 1959).

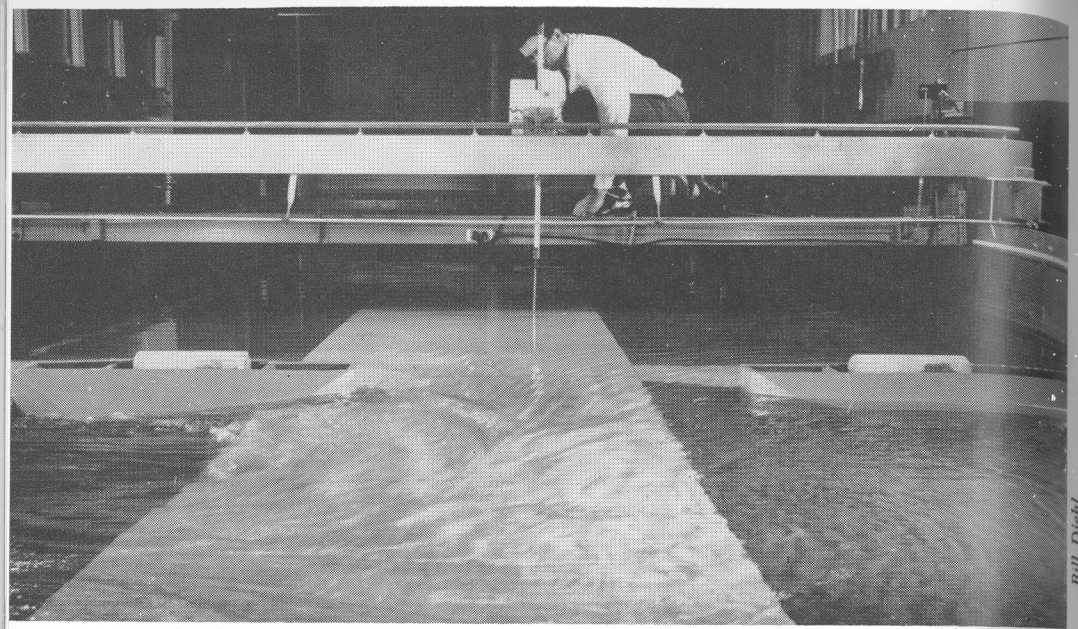
Research in mechanical engineering has included theoretical and experimental studies on the effects of acoustic vibrations on heat transfer and fluid flow. The little-understood relations between resonance and heat transfer have been investigated by means of specially-built apparatus in the Mechanical Engineering Laboratory. Preliminary data indicate that below approximately 145 decibels of sound pressure there is no appreciable acoustic effect on the heat transfer rate.

Research in aeronautical engineering continued to include a number of studies in the nine-foot wind tunnel. During the year these projects involved flutter and force questions regarding aircraft fuselages and empennage, wind effects on a missile service tower, and the influence of the hull on aerodynamic characteristics of submarine control surfaces. In addition to the wind tunnel studies, theoretical and experimental work on the air flow through helicopter rotors is continuing.

In the area of electro-mechanical devices for the Department of Defense,

HIGHWAY STUDY USES SIMULATED TIRE PRESSURES ON SAMPLE PAVEMENT.





PROJECTS IN HYDRAULICS USE A VARIETY OF OPEN-CHANNEL FLUMES.

two new projects were begun, both concerning equipment for medical research. One project involves the development of an experimental rotating beam and chair assembly, which will be used to determine the thesholds and sensitivities of human subjects to angular accelerations. This project is now in the design stage. Preliminary studies were also begun on the development of another rotating chair to stimulate parts of the human ear. The device will stimulate the labyrinthine passages in the inner ear to permit studies of the acceleration sensors and the subject's disorientation with respect to the surroundings.

Several interesting electro-mechanical studies were also made for industrial sponsors. One of the more significant projects was the development of meat-separating machines for the chicken industry. The separation of meat from the small neck and back bones of chicken posed a serious problem to processors. By means of a water flow feed system, the slight difference in densities of the meat and bone was utilized to effect a separation. The boneless meat is then quite suitable for use in soups, salads, etc. A stainless steel prototype of the machine was tested with success. The industrial sponsors of the project predict that the machine will be of great value to the chicken industry, which will be able to market profitably a great deal of meat previously sold at a loss.

A representative project in highway engineering research is the investigation of the stresses produced in a layered flexible pavement system by heavily loaded pneumatic tires. An embankment of compacted soil was constructed in a test pit. The soils selected for this embankment or subgrade were of the types that give trouble on Georgia highways because of their lack of high-load-carrying capacity.

Stresses in the subgrade are measured by 30 pressure cells embedded at three different levels in the subgrade.

Loading is by single, dual, and dual tandem tire assemblies with total axle loads up to 30,000 pounds. The measured stresses will be correlated with the physical properties of the subgrade, the base course, and the pavement.

Physical Sciences Division

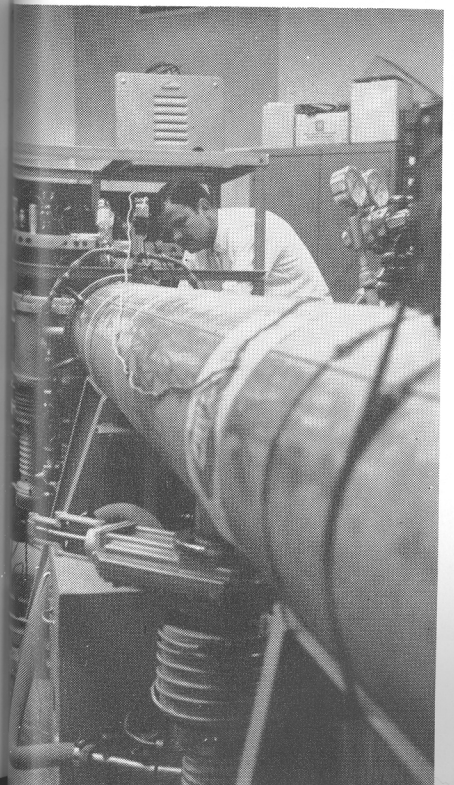
ONE OF THE MOST IMPORTANT developments during the year in the largest of the Station's divisions was the initiation of projects in a number of new, basic research areas. Outstanding new staff members were partly responsible for this expanding research effort.

Physics Branch

The addition of Dr. Edwin J. Scheibner enabled the Physics Branch to knit together previous work in solid state physics Dr. Scheibner also directed the equipping of a new high-vacuum laboratory, directed a contract sponsored by Wright Air Development Center, and continued his previous fundamental research in solid state physics.

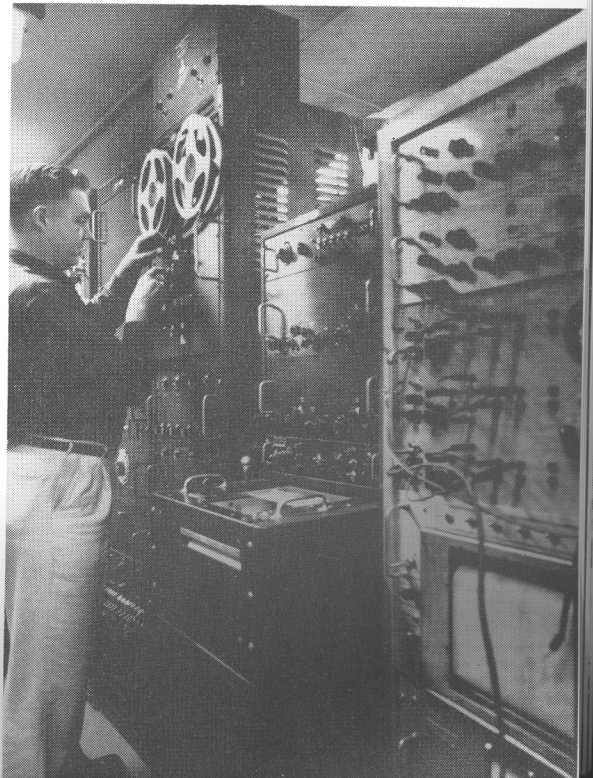
Work in a new research area for Georgia Tech—physics of the upper atmosphere—got underday with an Air Force contract soon after Dr. Howard D. Edwards joined the staff. The objective of this contract is to obtain fundamental knowledge of the atmospheric structure and composition at altitudes in excess of 100 kilometers. This objective is accomplished by observing with cameras, photometers, spectrographs, and other spectrophotographic equipment the movement

Long ion-molecule reaction chamber is part of apparatus for gaseous electronics study.



Bill Diehl

Equipment shown is used in research on radar, a major interest at Georgia Tech.



and reaction of visible clouds produced by explosive mixtures carried to altitude by rockets and missiles.

Another area in which Tech has just begun work is neutrino detection. Dr. Don S. Harmer, who joined the staff this year, continued his experiments in this field at the Savannah River project. Out of this work has come a major contribution to the experimental verification of the two-component neutrino theory and the principle of lepton conservation.

A fourth new area under investigation is under the direction of a long-time member of the staff, Dr. Earl McDaniel. To keep Georgia Tech abreast of new developments in plasma physics and thermonuclear reactions, Dr. McDaniel has spent time becoming familiar with the current literature and organizing a research program that will utilize the Van de Graaff accelerator.

Part of the initial work in all four of these areas has been supported through th use of State basic research funds.

In addition to these four areas, the Physics Branch carried out a great number of projects in the other areas under investigation. They include everything from x-ray diffraction and electron microscopy studies to studies of thin metal films as corrosion indicators.

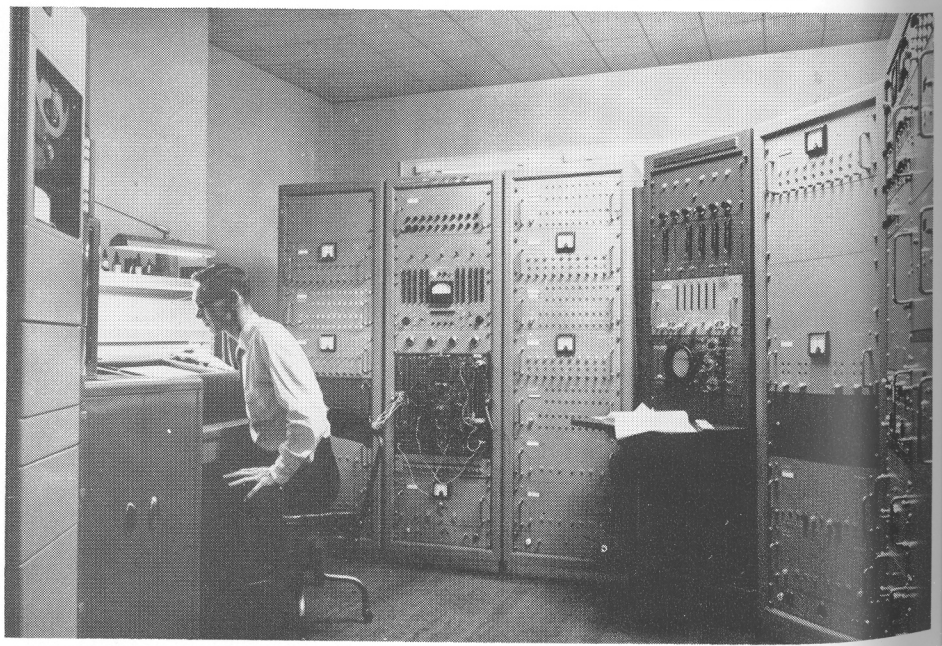
Radar Branch

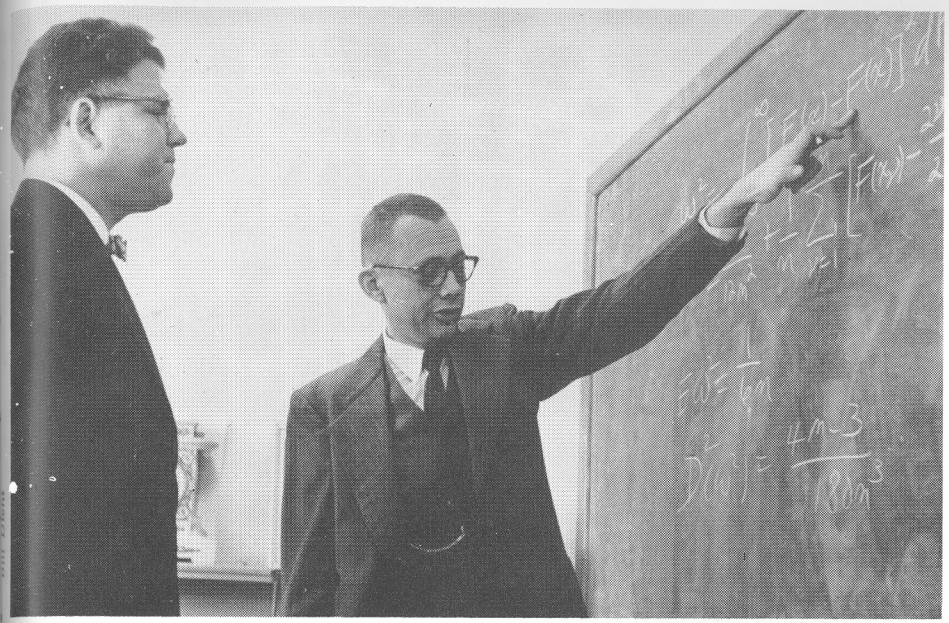
The Radar Branch continued to work in microwave propagation and scattering, microwave optics, millimeter components and techniques, radar system development and evaluation, and detection of microwaves. In addition, several new projects were begun during the year.

In one project—leading to the Ph.D. thesis of M. W. Long—the research effort was devoted to investigating means to improve the sensitivity of microwave spectrographs and to make theoretical and experimental investigations of the hyperfine spectra of molecules having three identical nuclei. The improved sensitivities obtained permitted the detection of very weak spectra of $CFCl_3$. No $CFCl_3$ lines had been previously observed. It is believed that these lines are the weakest ever measured.

ANALOG COMPUTER LABORATORY IS IMPORTANT IN SYSTEMS ANALYSIS.

Bill Diehl





CHALK AND PENCILS ARE THE TOOLS OF RESEARCH IN MATHEMATICS.

Analysis Branch

The Analysis Branch continued to concentrate in the general field of mathematical statistics. A typical project of this group concerned "A Statistical Model for the Pressure-as-a-Function-of-time Under the Ocean." For certain military applications a statistical model for underwater pressure fluctuations is useful. As a result of a preliminary examination of pressure records available to Tech researchers, they have conjectured that pressure fluctuations are *not* Gaussian, contrary to some theory and data published in the literature. A neat statistical analysis procedure has been devised for testing the normality hypothesis and for characterizing the pressure stochastic process in general.

This year also the Analysis Branch conducted a number of laboratory experiments in which interference-produced degradation in the performance of voice communications systems was measured by means of articulation tests (words scores obtained by a team of trained listeners).

The experiments concerned the "intelligibility threshold" of words and its relation to the power in the word. Studies were also made on the development of a new machine to estimate articulation scores.

Communications Branch

The research program of the Communications Branch continued in the areas of meteor and ionosphere scattering, interference of ground communications equipment, quartz crystals for frequency control, machine translation, and network theory.

In meteor scatter propagation, measurements on sporadic meteors have continued, but more effort has been concentrated on the observation of known showers.

In ionosphere-scatter experiments a fully equipped field site in South Atlanta is being used to measure reciprocal propagation in the ionosphere in conjunction with a similar station at Lincoln Laboratory, Massachusetts Institute of Technology.

Research in the area of frequency control has led to new knowledge of the modes of vibration of crystals at 3 mc. and the interaction of the modes and to more information on the behavior of circuits and equipment for the use of high-overtone modes for the control of frequencies above 150 mc. Crystals have been used successfully up to 300 mc.

Defense Branch

Research in the Defense Branch continued in the field of countermeasures with emphasis on the evaluation of systems and techniques. In addition the branch has the responsibility for the Analog Computer Laboratory.

One interesting project established during the year in this branch was "Physiologic Instrumentation Aids." This project covers phase one of a proposed two—or three-phase program to develop certain electronic devices for the Department of Pharmacology, Emory University Medical School. These devices will operate in conjunction with existing instrumentation so as to provide average heart-rate and blood pressure signals for recording along with instantaneous cardio-contractile forces and instantaneous blood-pressure readings during physio-pharmacological experiments.

AC Network Calculator

The purchase of new equipment for the network calculator increased its capacity by about 25 per cent. The enlargement enabled the computer to better represent the expanding electrical power systems in the Southeast. During the year the use of the network calculator for commercial work increased to a total of 42 weeks.

NEW AUXILIARY TAPE UNITS BOOST THE MEMORY OF THE 220 COMPUTER.

Rich Electronic Computer Center

MAJOR ADDITIONS and modifications of equipment have essentially doubled the Computer Center's capacity for service. This increased capacity was fully utilized during the year in computational work for research, education, government and industry. For instance, in the month of May, shortly after the installation of the Burroughs 220 (see page 7), the machine operated 326 hours, slightly better than double-shift operation.

The Computer Center has also continued to offer at least one seminar series of seven lectures each quarter on the use of digital computers. This seminar is open to all students and faculty at Georgia Tech.

The seminar program, coupled with the fact that an increasing number of departments are now using the digital computer as a classroom tool, has led to a widely expanded use of computers by faculty and students.

Sponsored research at the Computer Center has continued to cover a broad spectrum of computer applications. One of the more challenging studies is related to the problem of tracking space vehicles. The objectives of this project are (1) to conduct a review of the various mathematical processes in the numerical computation of satellite orbits through use of computers, (2) to ascertain the mathematical procedures best suited for orbit work to the degree of accuracy required and to make an error analysis of these procedures, and (3) to recommend the optimum orbital determination method for use on the 1103A computer. In addition, multiple precision routines for calculating functions such as Arcsin x, Arccos x, and other similar functions are to be developed.

In another sponsored project a nonprofit organization has utilized the facilities of the Computer Center in obtaining simple inter-correlations between psychological needs and mental illness. It is hoped that the resulting information will aid in describing the patterns of various types of mental illness. Much remains to be done in this new application of statistical analysis, and the digital computer will enable the organization to effectively pursue the research. In addition to computer programming service, the Computer Center is providing the sponsor with expert consultation on the design and use of statistical procedures.

Much of the research undertaken by the Computer Center is concerned with advancing the science of digital computer operation and maintenance. A number of projects in this area have involved the further development of program libraries for the various machines. The addition of several dozen new programs and routines during the year added greatly to the Computer Center's capability for service.

Other, more fundamental research is typified by the projects devoted to the development of digital computer circuitry and auxiliary equipment. Several aspects of the year's work in these areas attracted the interest and support of computer manufacturers.

Industrial Development Branch

CONTINUED RAPID GROWTH in the volume of research completed has characterized the Industrial Development Branch's third year of operation.

One of the most significant of the major new studies involves analysis of the types of industries that can be profitably located in the State's smaller communities and rural counties. Sponsored by the Georgia Department of Commerce, it will aim to identify a number of products which can be manufactured in the State's so-called "neediest" counties, many of which have been losing population at a steady and in some cases quite rapid rate. Research oriented toward the needs of these counties has been a weak link in Georgia's over-all industrial development program.

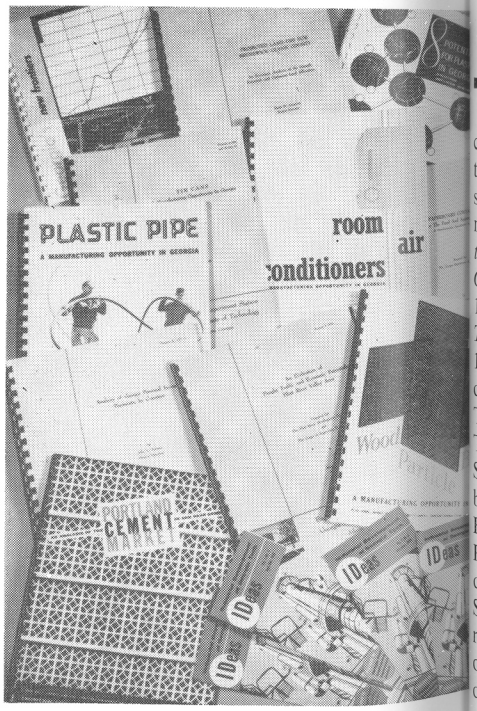
The first report released as part of this new project analyzes the possibility of developing the pelletizing of Coastal Bermuda grass as an industry for Georgia. Like an earlier study of the feasibility of locating a frozen food plant in a particular section of South Georgia, it is concerned with the processing of an agricultural crop. The intense interest which exists in such agriculture-based industries is shown in the fact that a $250,000 pelletizing plant was announced for Cairo, Georgia just before the report went to press. Another, smaller plant is already under construction in Sylvania.

A study of the problems and needs of small manufacturing firms in Georgia, undertaken under contract with the Small Business Administration, also will move in the direction of filling an existing void. The project is designed to offer needed assistance to the managements of many small plants. It will contribute also toward the achievement of one of the Branch's main aims: the further expansion or diversification of established industry.

Two projects relate to the development of the State's and area's river basin and waterway potentials. Already completed for the Flint River Development Committee is a compilation of river freight traffic tabulations, undertaken to provide data needed by the Corps of Engineers. A much larger project initiated in June involves an inventory and evaluation of data presently available on the industrial resources of five river basins, principally in Georgia but including also parts of North and South Carolina, Florida and Alabama.

The practical results possible through industrial development research were clearly demonstrated by one of the several product-industry studies completed during the year both for local development groups and for the Georgia Department of Commerce. Begun initially as part of work in progress for the Columbus Chamber of Commerce, the project was expected to reveal that the total market for tin cans in the Columbus area would justify the establishment of a can manufacturing plant there. Instead, new data furnished by the study revealed that the Atlanta area was the best location for a major can plant. As a result, two major companies have announced multi-million-dollar installations for Atlanta.

Carefully researched information is vital to the growth of industrial communities.
Van Toole

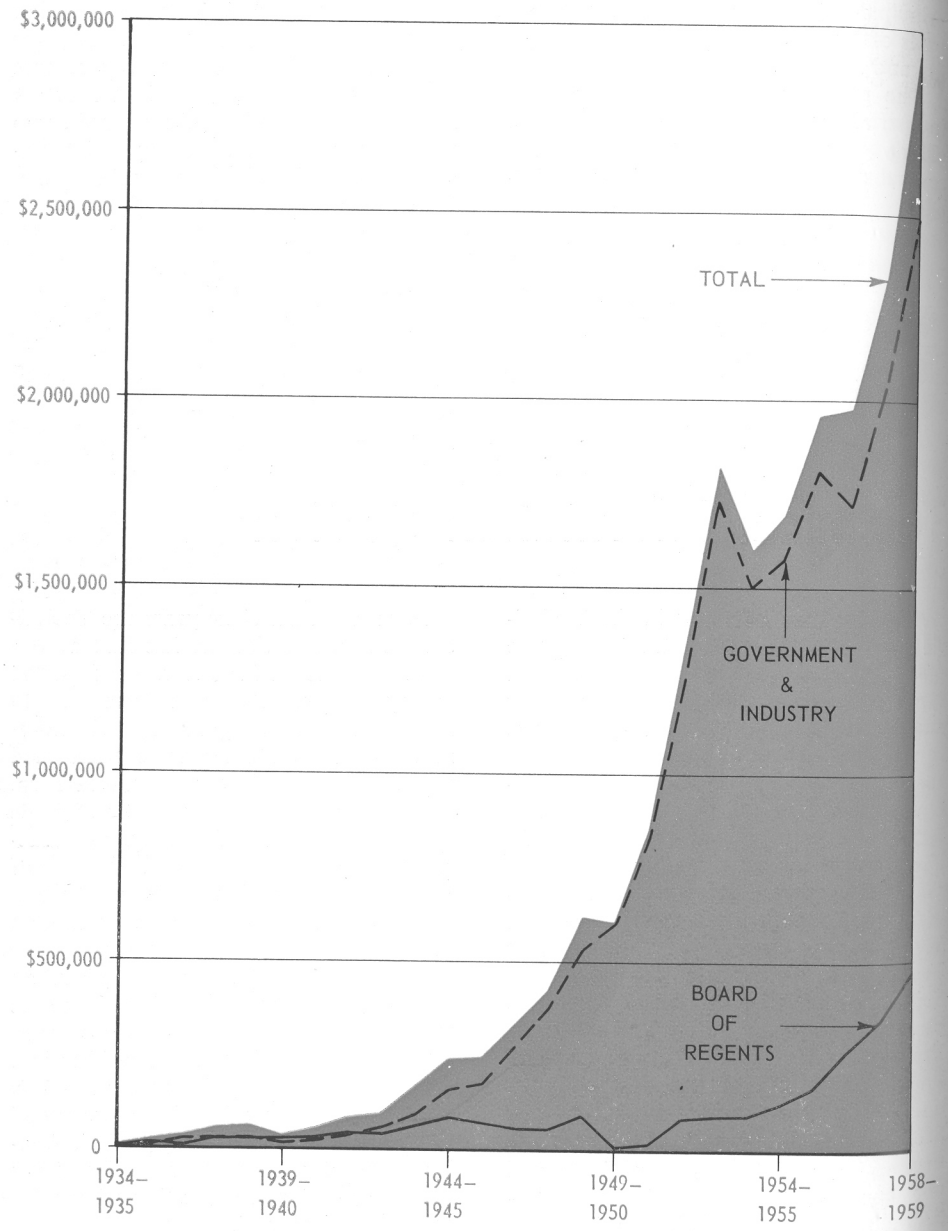


Technical Information Section

THE PRIMARY ACTIVITY in the Technical Information Section has been the compilation of a series of catalogs on all types of military antennas. Other major studies include supplemental literature reviews which will add to the *Review of the Literature of Two-Phase (Liquid-Gas) Fluid Flow in Pipes,* published in 1956, and to the *Bibliography on the Technology of Peanuts,* published in 1957. Literature studies were also conducted on the following subjects: Heat Transfer to Cryogenic Fluids, Heat Transfer in Vibrating Air Columns, Separation of Ripe and Unripe Peaches by Differences in Density, Thin Film Epitaxy, Bimetallic Films, and Uses of Phosphatides. Six of the projects conducted by the Technical Information Section were in support of other Engineering Experiment Station projects, and one supplemented work done in academic research programs.

For more than eight years the Technical Information Section has had a contract with the U. S. Government for the supply of technological information to industries in friendly foreign countries. A total of 13 studies were performed for Yugoslavia, Philippines, Costa Rica, Jamaica, Iraq, Mexico, Japan, and Chile on subjects varying from the manufacturer of fertilizers and the evaluation of new fibers for textiles to the production of bicycle inner tubes and the separation of lanolin for cosmetic purposes.

The *Monthly Literature Review,* an internal publication tailored to the needs of the Georgia Tech research programs, completed its sixth year of publication. The *Special Monthly Literature Review, Analog Computers* has been continued for the benefit of the Georgia Tech Analog Computer Laboratory staff and for analog computer facilities throughout this country and abroad.



The Station's Income by Source Over Its 25-Year History

DECEMBER, 1959

The Research Engineer

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FIREFLIES IN SPACE