# edited in retrospect

**an etch in time**

• The cover of this issue is the first commercial black and white application of the straight-line powderless etching process on copper perfected at the Georgia Tech Engineering Experiment Station. The new process was perfected for the Photoengravers Research, Inc., a non-profit organization of engravers from all over the Nation. Previously, the September issue of *The Photoengravers Bulletin,* official magazine of the American Photoengravers Association, carried a four-color cover etched in the Tech laboratories.

The cover photograph was taken by Georgia Tech photographer L. C. (Pappy) Prowse. It was printed as a positive and then taken to the engraving shop of Bradley and Son of Atlanta. From this positive a 120-line screen negative was made in such a manner as to retain, as closely as possible, the straight-line reproduction of the original. The one exception being that the highlight dots were made a little larger than would be required in the final reproduction. These screened negatives were printed to metal in the normal manner.

The plates were etched at Tech in one continuous operation in the bath previously proven in laboratory tests. In fact, the cover photo itself shows the spraying operation of this bath to etch a plate.

**the next issue**

• The success of the January, 1956, issue of the Research Engineer, which featured Tech's nuclear program, has prompted us to plan a progress report on this program for the coming issue. When we last reported this program to you it was strictly in the planning stage in its entirety. Today, the program is in the construction stage. The education phase has started with the present fall quarter. Money has been acquired by Tech for the radioisotope's laboratory which is in the hands of the architect. And, as you can see by the story on page 21 of this issue, some equipment of great value to the program has already been acquired. You'll get the complete story in January.

the research engineer JAN. 1957
Georgia Tech Engineering Experiment Station

# the research engineer

**VOLUME 12, NO. 1** **January, 1957**

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Georgia Institute of Technology, Atlanta, Georgia



**contents**



**the cover**

Research Engineer Tom Elliott, left, points out special design features of Georgia Tech's nearly-completed subcritical nuclear assembly to Research Associate Professor Earl McDaniel who will be responsible for its use in Tech's nuclear program. The assembly, being constructed in the Engineering Experiment Station, was designed by McDaniel and Elliott. The holes at the top of the assembly will hold the uranium rods in which will occur the nuclear fission initiated by a polonium-beryllium source to be located at the bottom of the assembly. The 6½-foot tank will be filled with water which will slow down the neutrons to allow a reaction as well as to act as safety shielding.

**Cover photo by Cecil Allen, of the Engineering Experiment Station**

**THE RESEARCH ENGINEER is published quarterly, in January, April, July and October by the Engineering Experiment Station, Georgia Institute of Technology. Entered as second-class matter September 1948 at the post office at Atlanta, Georgia under the act of August 24, 1912. Acceptance for mailing at the special rate of postage provided for in the act of February 28, 1952. Section 528, P.L.&R., authorized on October 18, 1948.**





# The most challenging Frontier

THE PESSIMISTS in this world who are constantly shouting that there are no more romantic frontiers for man to conquer haven't spent much time around today's scientific and technological centers. In these centers—industrial, governmental and educational—man is trying to conquer the most challenging of today's frontiers, the development of science through technology to make the world a better place in which to live.

Among the most laudable of these achievements has been the way that man has turned scientific discoveries once used as instruments of destruction of man into developments that are now adding to a better way of life for the people of the world. There are hundreds of examples of man's harnessing of wartime achievements for the benefit of the peacetime world. But probably the most striking of these developments by science and technology have been saved for today's biggest challenge—making the atom work for man's good and not his ultimate destruction.

Already, the work that scientists and engineers have been doing for the past decade in the nuclear field is starting to pay off in better living. Certain industries can offer better products at lower costs, because they have saved many millions of dollars through the use of radioisotopes in quality control. We are promised a better, longer life because of the use of radioisotopes in medical treatment. There is great promise for cheaper, more-plentiful power to help ease the problems of the power-short areas of the world. And through this scientific research we are gaining a better understanding of the world in which we live.

If these great benefits are to continue to increase, we must rectify our one great shortage in the nuclear as well as all of the scientific and technological fields—the shortage of trained manpower. Basically, it is to help ease this shortage, that Georgia Tech's nuclear program outlined on the following pages is aimed. This program of education and attendant research is our basic mission in all the fields in which we are engaged. We intend to carry it out to the best of our abilities.

Paul Weber
*Acting President*

# THE SOUTH AND THE ATOM

Educated manpower, typified by this Oak Ridge research chemist is today's greatest shortage in scientific and engineering fields.

by M. L. Meeks
Research Associate Professor

—*AEC Photo by J. E. Westcott*

## The secretary of the Georgia Tech Nuclear Science Committee takes a look at the problems of nuclear development for Georgia Tech and the entire South

DURING THE YEAR 1956, the South took a giant step forward in the nuclear field. Following a directive of the Southern Governor's Conference held at Point Clear, Alabama, on October 20, 1955, a region-wide series of conferences was held to plot the course of Southern development in the field of nuclear energy. The recommendations of this study[1] set forth specific ways in which the individual states and the South as a whole can move to use the atom in agriculture, industry, and medicine.

Governor Marvin Griffin gave his wholehearted support to these plans and moved quickly to bring Georgia to the front. The Georgia Nuclear Advisory Commission was appointed, following recommendations of the Work Conference on Nuclear Energy, and a grant of $300,000 was made available to Georgia Tech. This grant was for the construction of a radioisotopes laboratory and a student neutron physics laboratory. The grant made it possible for Tech to begin its master's degree program in nuclear engineering and nuclear science during the current academic year. Governor Griffin also indicated his desire to make available about $2,500,000 to permit the construction of a high-flux research reactor at Georgia Tech. This truly splendid support of the nuclear program of education and research will permit Georgia Tech to move toward a position of leadership in the nation as well as in the South.

As a result of staff work performed by the Southern Regional Education Board and its consultants for the Nuclear Energy Conferences, it is possible to see more clearly the particular problems that the South faces and the particular advantages that the South possesses in the nuclear field. The principal problem, not only in the South but in the nation as a whole, is the shortage of well-trained scientists and engineers. The shortage is clearly apparent at the bachelor's degree level, but at the master's and doctor's degree level the shortage is truly crucial.

The South's most serious bottleneck in putting the atom to work is its failure to produce enough scientists and engineers at the graduate level. This deficiency in well-trained Southern manpower is very serious indeed. The sixteen southern states partici-

*"We are making great progress all over the South, but we should not let our gains lull us into any false sense of security. We are not out of the woods, by any means. Industry-wise, the South is still an infant. Despite our recent industrial growth, the South actually may be in serious danger of being left further behind by the rest of the nation.*

*"Now, however, with the advent of the atomic age, the whole picture of industrial life can be and probably will be changed. Atomic power, for heat or for generating electric current, can wipe out the geographic handicaps of lack of water power, coal or oil.*

*"Left to chance, however, nuclear energy for industrial use will gravitate to the existing industrial areas, mostly in the North. The South, already short of industry, is likely to be left still further behind unless we do something about it.*

*"Nuclear energy can mean the economic emancipation of the South. But the South must act as a whole, and in my judgment, the moment of decision is now.*

*"The challenge to the South is to make industry follow the atom, and not stand idle and permit the atom to follow existing industry. If we are to bring the atom to the South, it will take immediate joint planning and action among the Southern states on a regional basis, and on a bold and progressive scale beyond anything yet attempted."*

Governor Leroy Collins of Florida at Point Clear, Alabama, 1955

**South and the Atom—cont.**

pating in the nuclear energy conferences have almost exactly one-third of the nation's college-age population. These same states now produce about one-fourth of the bachelor's degrees in science and engineering. At the same time, however, these states produce only about 16 percent of the master's degrees and only about 12 percent of the doctor's degrees in science and engineering.

Looking at our state the picture is even more gloomy: Georgia ranked twelfth among the sixteen southern states in the productivity of scientific and engineering doctorates during the years 1954-55. Georgia produced 20 while North Carolina produced 88, Tennessee produced 45, and Florida produced 41. There is consequently a tremendous need for expansion of graduate facilities on a broad front including agriculture, engineering, the physical sciences and the life sciences. The nuclear program at Georgia Tech can be expected to give support to such an expansion in the physical sciences and engineering but Georgia and the South have a long way to go to reach equality with other regions of the nation. The dividends from broad and vigorous graduate programs once achieved can be enormous. Such programs would not only produce the manpower needed for Southern leadership but would produce new techniques and processes for agriculture, industry, and medicine.

As potential markets for nuclear power, the southern states differ widely. A survey prepared by Dr. Karl Mayer of the Stanford Research Institute for the Southern Regional Education Board shows that nuclear power generated at lower and lower costs will produce a major impact in the states of Georgia, Florida, North Carolina and Virginia, while such states as Mississippi, Louisiana, Kentucky and Texas will receive a comparatively minor impact in the years ahead. Figure 1 shows the results of this impact analysis. A "major" impact is defined as a potential loss of more than 15 per cent of the conventional power market to nuclear power that could be generated at 6 mills per kilowatt hour. An "intermediate" impact is a loss of 5-15 percent of the market to 6-mill nuclear power and a "minor" impact is a loss of 0-5 percent of the market to nuclear power. Georgia Tech's nuclear program can be of considerable assistance in providing manpower knowledge, and specialized research facilities for Georgia and the other states in which nuclear power is expected to produce a major impact.

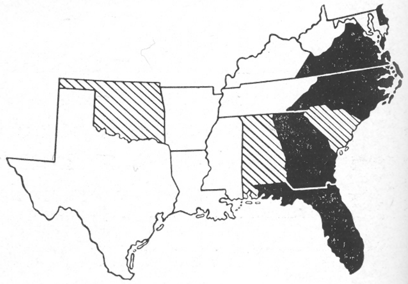



Figure 1 — analysis of potential impact of nuclear power in the South as of 1956.

Governor Marvin Griffin, second from left, and Board of Regents Chairman Robert O. Arnold, left are briefed by Oak Ridge personnel on the capabilities of the swimming-pool-type reactor during a recent visit to the Atomic Energy Commission's installation.

A recent survey by the Southern Regional Education Board shows that the southern universities are currently lagging behind those of other regions in providing nuclear research facilities. In spite of this deficiency, southern universities have been able to make some significant progress with the assistance of the Oak Ridge Institute of Nuclear Studies. This organization has permitted faculty members to work at the Oak Ridge National Laboratory during summers and has provided for members of that Laboratory to visit various institutions for lectures and discussions. Georgia Tech has made extensive use of these arrangements and has received great benefit from them.

But, in the long run, the research facilities at Oak Ridge can never take the place of facilities on the campus. Additional research facilities must be obtained to serve the educational and research needs of the individual institutions in the southern states. The efficient build-up of such facilities will require cooperation between institutions within each state and between the various southern states. Such cooperation will insure that expensive facilities are fully used and not needlessly duplicated. Georgia Tech recognizes this need for cooperation and the exchange of ideas between institutions. As planning for Tech's research reactor proceeds a strong effort is being made to include features which will make this facility able to serve other fields such as medicine, agriculture, and the life sciences. This will, it is hoped, insure the value of this facility to the entire State and to the South.

**references**

[1]*Role of Atomic Energy in the South,* Recommendations of the Work Conference on Nuclear Energy, St. Petersburg, Florida, August 1-4, 1956. Published by the Southern Regional Education Board, 881 Peachtree Street, N. E., Atlanta 9, Georgia.

A Progress Report

# Nuclear Education at Georgia Tech

by L. David Wyly, Jr., Professor, Physics School

DURING THE PAST YEAR the need for engineers and scientists who are trained to work in the nuclear field (particularly in the area of nuclear power) has become acute. Members of the Atomic Energy Commission have repeatedly pointed out that the nation's technological advancement in the commercial use of nuclear power is seriously limited by the lack of scientific manpower. The past year has also seen the entrance of many of our big industrial companies into the nuclear power field. In the face of an already extreme shortage of engineering and science graduates, the critical need for *nuclear* training has presented a major challenge to our engineering schools.

Georgia Tech anticipated the need for *nuclear* training by the appointment of the Education Subcommittee two years ago. The initial progress report of this subcommittee in last January's *The Research Engineer* stated, "In order to meet the need for well educated modern engineers, Georgia Tech must offer courses of study in nuclear science and technology. There will be an increasing demand for engineers in the present engineering disciplines who are better grounded in the fundamentals of their field and who also have a basic knowledge of nuclear science and of how their field of specialization may be applied to nuclear engineering problems. Proposals for additional courses and laboratories which are desirable to strengthen our educational program in nuclear science will soon be presented to the Graduate Council. The majority of the new courses will be introduced at the graduate level in order to permit the student to apply this work to his field of specialization. A program of study leading to the Master's Degree in Nuclear Engineering is under consideration."

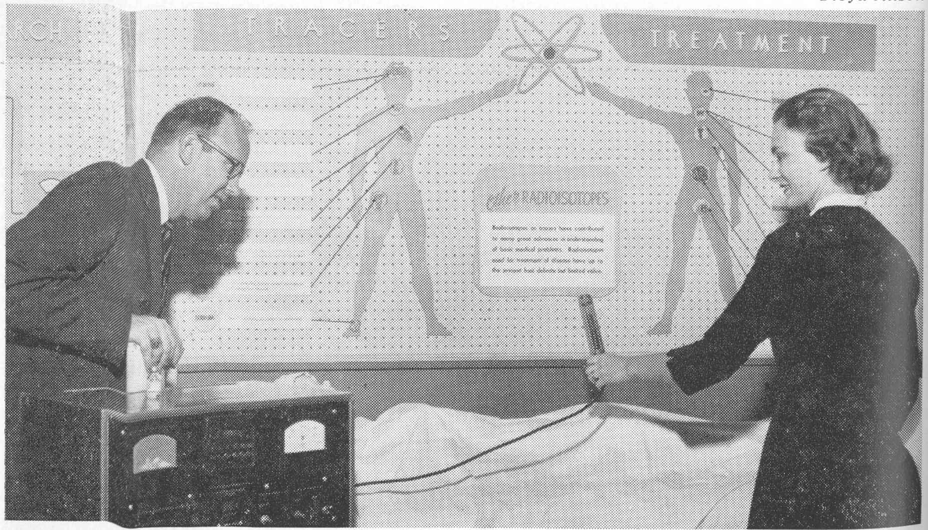
Last spring the Graduate Council approved programs of study leading to the Master of Science degrees in Nuclear Engineering and Nuclear Science. The Board of Regents, in turn, approved the granting of these degrees by Georgia Tech. The request to the Graduate Council also outlined a course of study for students entering this program. Very briefly it was as follows: A student desiring such a degree would enter graduate school in the School of his B.S. degree (e.g. M.E., E.E., Ch. E., Chem., etc.) where he would take approximately half of his master's degree work; the other half of his work would be in the specific fields of nuclear science and engineering and mathematics. Such a program offers the dual advantage of aiding the building up of *nuclear programs* in the individual schools and offering a specific program in nuclear science and engineering to those students with particular interest in the commercial utilization of nuclear energy. One of the difficulties in setting up a detailed course of study in such a rapidly growing science is keeping the program up to date. The Graduate Council therefore appointed a committee, with Dr. J. M. DallaVale as chairman, to oversee the curriculum and keep it up to date.

During the summer, several of our faculty members attended the Summer Nuclear Energy Institutes at the Argonne and Brookhaven National Laboratories in order to better equip themselves to teach the *nuclear* courses.

One of the major problems which faced the school was the need to furnish and equip the necessary laboratories. The new radisisotopes buildings will furnish laboratory space of such courses as radiochemistry, experimental reactor physics, and biological effects of radiation. One indication of the status of this program may be found in the progress of the experimental reactor physics laboratory. A subcritical assembly is at present under construction for this laboratory and will be used in a temporary location until the radioisotopes laboratory is completed. (A subcritical assembly is a small reactor which will not produce power. It does not require expensive shielding, yet it may be used to study the important design features of reactors.) The A.E.C. loaned Georgia Tech 2.7 tons of uranium to construct this excellent laboratory facility. Dr. E. W. McDaniel is busy completing this facility in order to be able to give the experimental reactor physics laboratory during the spring quarter of this year.

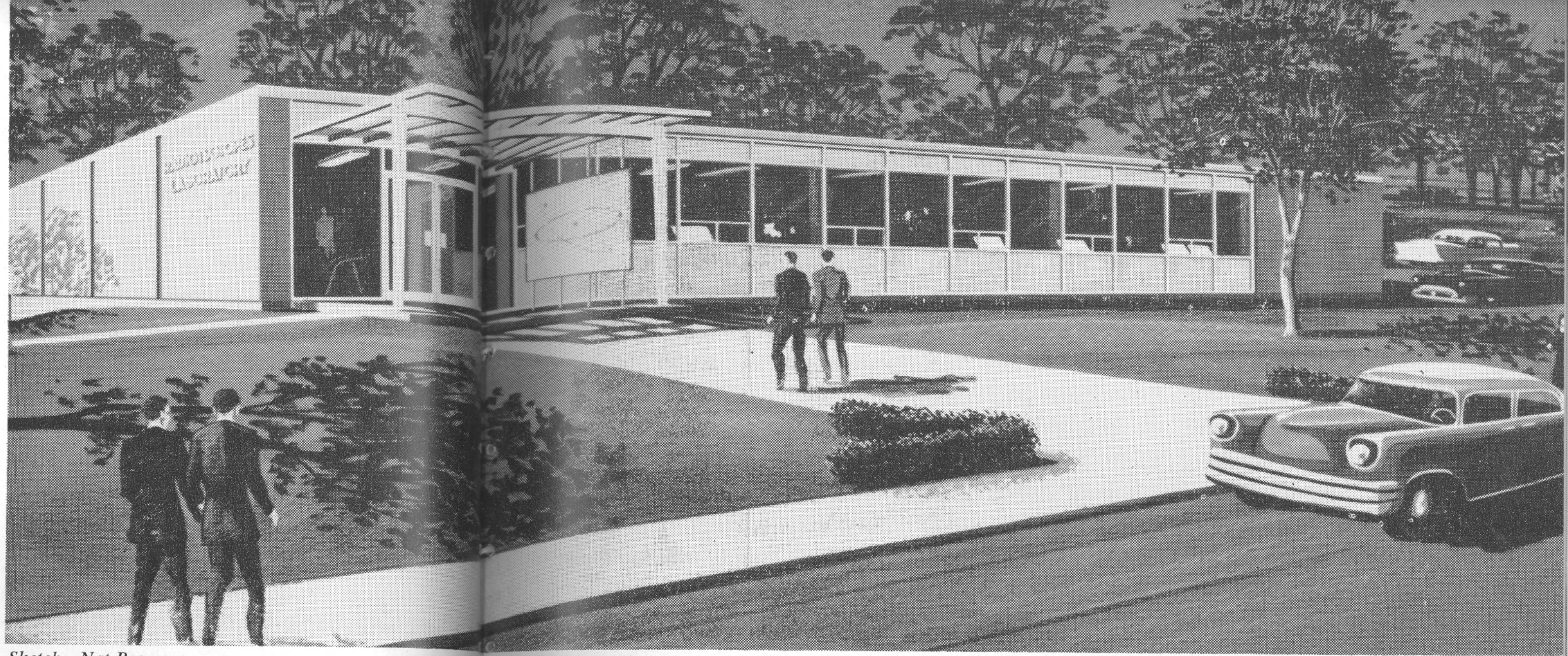
The past year has been most significant in Georgia Tech's progress. All those courses and laboratories which were deemed essential to offer the nuclear degrees are now being offered. In addition many other courses directly applicable to the problems of nuclear engineering have been introduced into our curriculum as a comparison of the last two years catalogues will show. Even more significant, is the change in courses content of the other curricula on the campus. If Georgia Tech is to maintain its position of prominence in engineering education it must, of course, equip its students to work in tomorrow's world. It must teach well the fundamentals of science and engineering for the fundamentals don't change — only the technological applications change. The continual modernization of Tech's curriculum is the best proof of our progress.

Floyd Jillson




GRADUATE STUDENTS WINSTON BOTELER AND MARYLY VAN LEER PECK VISIT THE AMERICAN MUSEUM OF ATOMIC ENERGY AT OAK RIDGE.


Graduate student Sam Barnett takes in the radioactive plant display at the museum.




Sketch—Nat Browne

Architect—John W. Cherry

The architect's sketch of Georgia Tech's new Radioisotopes Laboratory. The building will go under construction in the near future and will furnish laboratory space for research as well as for student lectures.

A Progress Report

# GEORGIA TECH'S RADIOISOTOPES LABORATORY

**by Raymond G. Wymer**
**Research Associate Professor**

IN THE JANUARY 1956 ISSUE of *The Research Engineer* the need for a radioisotopes laboratory for instruction and research at Georgia Tech was clearly spelled out. In addition, the basic features of the building and its general functions were indicated. At the present time—one year later—preliminary plans for a 9,680-square-feet radioisotopes laboratory have been approved by the State Board of Regents, and $300,000 has been made available by the State of Georgia, through Governor Marvin Griffin, for constructing and equipping the building. The radioisotopes laboratory will provide laboratory space and facilities for courses taught in connection with the graduate program in nuclear science and engineering and for research.

The plan provides for a one-story building initially, with provisions for a second, and finally, for a third floor, as the need arises. A subcritical assembly intended for instructional purposes will be located in a large physics instruction laboratory. There is a similar large radiochemistry instruction laboratory and three smaller research laboratories, as well as a storage and handling laboratory for materials containing up to approximately one curie of radioactivity. Office space for faculty and staff has also been provided, as have a counting room and an electronics shop. The plan has been based, in large part, on the design of the highly successful and flexible laboratories in the principal research laboratory building at Oak Ridge National Laboratory (the 4500 building).

The completely air-conditioned building is based on twelve-foot modules, with the laboratory area in the center of the building, and corridors and offices on both sides. A short transverse corridor connects the side corridors and provides access to additional modules along the front of the building.

It is not intended that all campus activities employing radioisotopes be confined exclusively to the radioisotopes laboratory, but the laboratory will provide a central facility for receiving and storing radioisotopes, and will be so well suited to such work that most of it will be done there as a matter of convenience.

Present plans are for research in the three major fields of radiochemistry, radiation chemistry, and radioactive waste disposal to be carried out in the radioisotopes laboratory, as well as for support of research associated with the proposed research reactor.

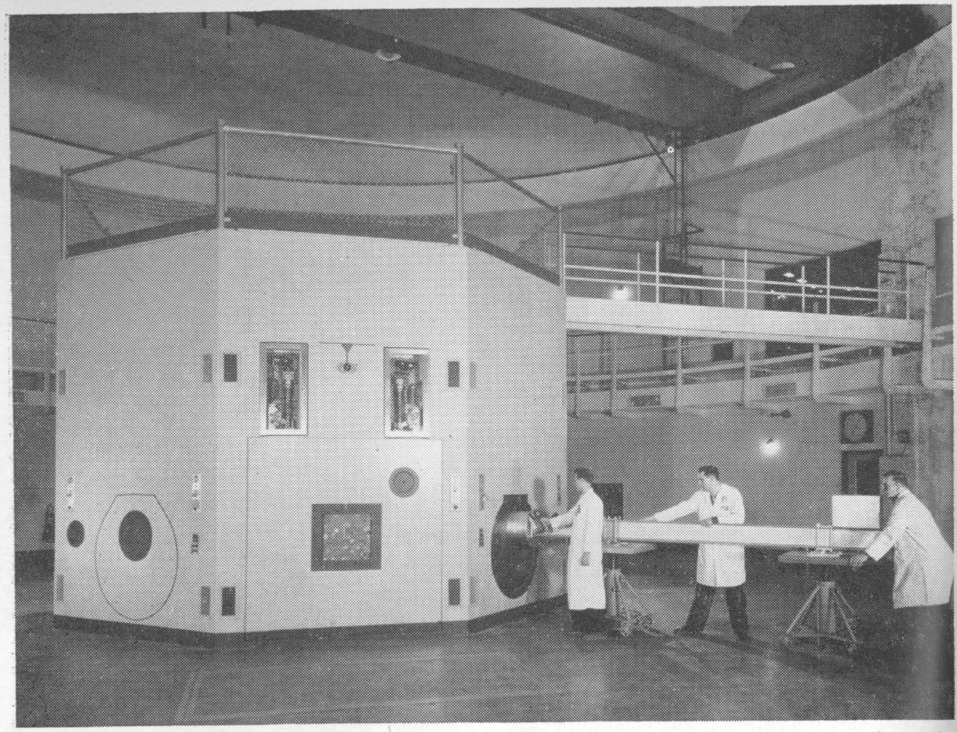
Radiochemical research will include studies of chemical processing of simulated spent reactor fuels, and basic studies of complex ion formation in aqueous media using radio-tracers. A small solvent extraction column and a continuous resin contactor will be used in part of this research.

Radiation chemistry research will include studies of the effects of gamma, beta, and neutron radiation on organic and inorganic systems, and also of the effects of intense x-ray irradiation on these systems. The former irradiations will require the use of a research reactor; the latter, an x-ray machine. Both animate and inanimate organic systems will be studied.

Radioactive waste disposal research will include studies of the removal of radionuclides from water, fission product fixation and disposal, and the effects of radioactivity on industrial and domestic sludges.

In addition to housing this broad and far-reaching program of research, the radioisotopes laboratory will provide outstanding facilities for many of the laboratory courses taught in connection with the educational program in nuclear science and engineering. The progress of this program is discussed in more detail elsewhere in this issue.

There can be no question that the radioisotopes laboratory described above will place Georgia Tech among the best-equipped educational institutions in the United States for nuclear science and engineering training and research using radioisotopes. Such a fine facility will make much easier the highly important task of attracting additional competent scientists and engineers to Tech. In the last analysis, it is these scientists and engineers who will place Georgia Tech among the leading educational institutions in the training of nuclear scientists and engineers, and in research in this field of great promise and vast potentialities.



The AEC's new CP-5 reactor locate at Argonne National Laboratory is representative of the heavy-water-moderated type. It uses $U^{235}$ as fuel and is one of the major types under consideration for Tech. Access to the neutrons created within the reactor is made possible by more than 50 openings which penetrate the 8 sides and top of the reactor. Operation is controlled by technicians in the control room, upper right of this picture.

**A Progress Report**

# Georgia Tech and the research reactor

**by William B. Harrison, III**
**Professor, Mechanical Engineering**

THE REACTOR SUBCOMMITTEE of the Georgia Tech Nuclear Science Committee was established to determine the needs at Georgia Tech for reactor facilities, and to supply the Nuclear Science Committee and the entire faculty with information on reactor types and their research potential. In this progress report, some of the conclusions and recommendations of the Reactor Subcommittee are reviewed.

For purposes of this discussion, a reactor may be considered in very simple terms as a source of heat, neutrons, and gamma rays. (Neutrons are very small particles which constitute part of the nuclear structure of atoms. Gamma rays are very penetrating rays much like the more familiar x-rays.)

Reactors utilizing the heat for the production of power are generally called power reactors. Similarly, reactors utilizing the neutrons and gamma rays primarily to produce radioisotopes or other reactor materials are sometimes called production reactors. A third classification refers to the reactors which offer the maximum use of these neutrons and gamma rays for experimental investigations. Such reactors are called research reactors. These are the reactors of interest to Georgia Tech.

In the evaluation of a proposal for a research reactor at Georgia Tech, consider first the ways in which the State of Georgia and Georgia Tech would benefit from such a facility:

1. The State of Georgia has an unprecedented opportunity to become a leader in the research leading to applications of nuclear energy. The predictable future for applications of nuclear energy already is so large in scope as to stagger the imagination. Every field of scientific endeavor contributing to the present progress in the South will be expanded and improved by an active interaction with the fields of research related to nuclear energy. At the present time there are many known applications of radioisotopes, which are made in nuclear reactors, to research in medicine, physics, chemistry, biology, animal husbandry, agriculture, and engineering. Every advance in these fields then offers a broader base from which further advances can be made. An investment in nuclear science and engineering, specifically in the research and education centered about a modern research facility, will pay large dividends to the State of Georgia and the South.

2. A research reactor facility is becoming established as required equipment in academic institutions of the size and character of Georgia Tech. Regarding nuclear science, the Education Subcommittee of the Nuclear Science Committee has "deemed it imperative that Georgia Tech offer training in this field if it is to maintain its position of prominence in engineering education." By the same reasoning, a strong motivation for acquisition of a research reactor is the desire to meet academic competition. In the August 1955 issue of *Nucleonics*, it was stated that 30 U. S. universities are considering research reactors, including the reactors now in existence or being constructed at North Carolina State College, University of California at Los Angeles, Illinois Institute of Technology, University of Michigan, Pennsylvania State College and Massachusetts Institute of Technology. Of particular interest in the Southeast are reactor considerations by Vanderbilt University and the University of Florida. To the entire country, the reactor symbolizes a new era of nuclear energy and related research and the lack of a reactor facility can be construed as a deficiency with respect to the advances of science and technology. If Georgia Tech is to maintain a reputation of leadership in research and education, acquisition of a research reactor is highly desirable.

3. A research reactor would provide for research possibilities which are presently of interest but impossible at Georgia Tech. For example, a reactor would make available isotopes of short half-life (radioactive materials which lose their radioactivity in a short time). This would open up fields of research which are impossible except in the vicinity of a reactor. In a recent survey of interests among various staff members at Georgia Tech, Dr. Earl McDaniel found particular interests in reactor facilities for neutron diffraction, neutron spectroscopy, activation analysis, radioisotopes production, studies of effects of radiation on properties of materials, and other research subjects. It is noted also that more than forty of Tech's faculty members have had previous experience in nuclear fields.

4. The staff members of the Engineering Experiment Station have recently had the opportunity to consider two requests for research proposals from outside agencies which would involve the use of a nuclear reactor. This is considered to be an additional indication of the existing need which would be met by a research reactor facility.

5. The presence of a research reactor facility at Georgia Tech would motivate interests of the staff in new directions. At present, there can be no stimulus for certain lines of thought, be-

cause facilities do not exist for reducing the ideas to practice. It is believed that the presence of a reactor would generate many new approaches to engineering problems, bringing technical advances, recognition of staff contributions, and associated credit to the institution.

6. A research reactor would strengthen the educational program in nuclear science. The strength would come from the fact that the reactor embodies many principles which can be demonstrated to students in nuclear science. It would also serve as a center of graduate research activity in the field of nuclear science. In particular, a research reactor would provide excellent facilities for doctorate thesis research in the basic and engineering sciences.

7. A research reactor would serve as an added inducement for competent scientists and graduate students to come to Georgia Tech, thereby helping to insure continued advancement in science and technology. Dr. C. F. Von der Lage, formerly Director of the Oak Ridge School of Reactor Technology, has expressed the thought that this ability to attract and hold competent men is one of the principal values of having a reactor connected with a university.

8. A research reactor, as any other major facility of the Institute (for example, the Computer Center), would increase the scope of operations which can be employed in research and educational problems, thereby increasing the potential of the institution for service to the country and the State of Georgia as well as for gaining additional supported research programs.

9. The existence of a reactor in the Atlanta area will be an inducement for certain industrial concerns to locate in Georgia, bringing increased revenue to the area.

10. A research reactor for Georgia Tech would serve other interests in the Atlanta area. Contact with Lockheed Aircraft Corporation has indicated a region of strong mutual interest both in education and research in the field of nuclear science. The Georgia Power Company participates with the Atomic Power Development Associates and it is very likely that Georgia Tech can make a unique contribution to their program in the future. Certain activities at Emory University would also benefit by a reactor in Atlanta. For example, Dr. H. D. Bruner, Chairman of the Department of Physiology in the Emory School of Medicine, has stated that there is an immediate need at Emory for short half-life isotopes in medical research. These short half-life isotopes are available only in the vicinity of their source. In addition, Dr. Walter Cargill, of the Veterans Hospital in Atlanta, has recently pointed out the needs for using a reactor as a source of neutrons for neutron therapy. He feels that such a facility in the Atlanta area could provide for the needs of a large portion of the Southeast.

### the reactor selection

In order to enjoy all of these benefits, the most advanced, yet practical, reactor system is indicated. It would be highly desirable to have a reactor system with special features not incorporated in reactor systems at other academic institutions. Also, it has been concluded by the members of the Reactor Subcommittee, that interests at Georgia Tech can be served best by what is called a high-flux reactor (with a peak flux of at least $5 \times 10^{13}$ neutrons/cm.$^2$ sec.). This would be adequate for the research interests already defined by the staff, and it is considered to be the minimum practical peak flux to provide for other research of potential interest or importance. The thought of the Reactor Subcommittee is that the low-power, low-flux, and relatively low-cost installations are not going to fulfill the objectives of the builders, because the reactor will not permit work in the regions of expanding interest.

The primary functions of a reactor facility in an academic institution should be research and education. Efforts to produce useful power from a given type of reactor either reduce the research possibilities or add greatly to the cost. By this line of reasoning, the Reactor Subcommittee has concluded that it is inadvisable to attempt both power production and research in one reactor, and that emphasis should be placed on maximum research possibilities consistent with the recommendations for high neutron flux.

Another conclusion is based on limitations of the financial status of such an undertaking as a reactor project for Georgia Tech. It appears at the outset that Georgia Tech could never justify the expense of the design and development of a completely unique reactor system. On the other hand, several diversified research reactor types have already been developed at the various National Laboratories (Argonne, Oak Ridge, Brookhaven, and Los Alamos) and some of these types are currently being manufactured and marketed by private industrial concerns. Taking into account this situation, the members of the Reactor Subcommittee have limited recommendations for reactor systems for Georgia Tech to the field of possibilities which have already been designed and developed, so that Georgia Tech may be spared part of this financial burden.

Of these reactor types developed in the National Laboratories, at least two appear to satisfy the needs at Georgia Tech. A reactor engineer would probably identify them as (1) light-water moderated, enriched fuel, heterogeneous, tank-type reactor and (2) heavy-water moderated, enriched fuel, heterogeneous, tank-type reactor. In further reference to them, they will be called simply the light-water reactor and the heavy-water reactor.

### the reactor cost

Even with the policy of the U. S. Atomic Energy Commission to give fuel and certain other expensive reactor materials to academic institutions, high-flux research reactors are very costly. Of the two types under consideration, each will require capital investments of the order of $3,000,000 to $4,000,000 for the reactor, the building, and a modest amount of research apparatus. Each will require annual operating cost of $200,000.

### staff problems

The members of the Reactor Subcommittee feel strongly that Georgia Tech should not compromise by purchasing a low-flux reactor, for then the possibilities for advanced research and the potential market for research would become negligible. There exists the possibility that financial assistance can be found for defraying the initial expense and operating costs.

In addition to these high costs already mentioned, it seems appropriate to point out that technical personnel to staff the research facility are also expensive. The supply of trained personnel is limited, and the nuclear energy industry is expanding very rapidly. The result is that in order to acquire needed staff members, Georgia Tech must be prepared to offer competitive salaries and other inducements, though they may be out of line with present salary scales at Georgia Tech.

The high capital investment and operating cost of a high-flux reactor and the difficulty of hiring highly qualified personnel represent the most serious obstacles to a reactor program at Georgia Tech. Some effort has been made to estimate the extent to which the operating cost could be underwritten by sponsored research, but the results are inconclusive. The biggest hope for sponsored research appears to rest with government agencies or government prime contractors in connection with the present large-scale programs involving nuclear powered aircraft and missiles. There is no sure way to predict the future demand, but there are factors which indicate a bright outlook. For example, Westinghouse personnel make the point clear that the Westinghouse Test Reactor is conceived specifically as a money-making venture. In fact, they will consider selling a duplicate of their facility with which they would share part of the research market.

In brief, the reactor required to satisfy the needs at Georgia Tech is an expensive item, but the potential dividends from the investment are tremendous.

A Special Report

# Fissionable materials in Georgia's rocks

by Clifford N. Chancey, Jr., John Fields, Walter S. Fleming
Earl W. McDaniel, Alfred T. Navarre and H. W. Straley, III

THE NECESSITY for supplementing our conventional energy sources with nuclear energy has become abundantly clear in the last few years. Examination of the rapidly increasing rate of power consumption and the estimated conventional power capabilities indicates that fossil fuels and water power can continue to satisfy the world's demand for only a few centuries at most.

At present, most of the United States' uranium comes from the Colorado Plateau and Great Bear Lake, Canada. Large quantities of high-grade ore exist there and elsewhere, but we must look ahead to a time when these supplies will be exhausted. It is imperative that we assess all of our nuclear energy resources and make a major effort to improve the methods of extracting fissionable materials from low-grade ores.

Several groups of scientists have been working on the problem of the economical recovery of fissionable materials from low-grade minerals and considerable progress has been made. In particular, techniques for the cheap extraction of uranium and thorium from granite have been developed. Although the utilization of low-grade rocks as fuel sources is not competitive with that of fossil fuels from the standpoint of the money and energy required for processing, it will probably become extremely important as our supply of conventional fuel and high-grade ore shrinks.

In the light of this situation, a project was established at the Georgia Tech Engineering Experiment Station in late 1955, one of the main objectives of which was to survey the uranium and thorium content of Georgia's granites, sands, and other rocks.

At the outset of the project, quarrymen throughout the state were requested to submit samples for analysis. The response was good. Samples were received from some eight or ten quarries near Elberton, Lithonia, and Tate. A large number of granite samples were obtained from Vernon J. Hurst, Georgia Department of Mines, Mining, and Geology. Sand samples were secured from the Coastal Plain, sedimentary rock from northwestern counties, rocks other than granite from middle Georgia and the gold belt, and pegmatites from Monroe and White Counties.

GRANITE: More than half of the granite producers have kindly sent material. In most instances, it was collected from a quarry face and the name of quarry supplied. In some the quarry positon and depth below topographic surface were included. A large proportion of the samples comes from the area covered by the Elberton Granite Association, our thanks to its Secretary, Mr. William A. Kelly.

NORTHWEST GEORGIA: Contractors for the Atomic Energy Commission were contacted to make sure that there would be no conflict of interest or duplication of work. We were assured that there was no intention, at that time, of coming into Georgia to collect samples of Chattanooga (Mississippian) shale or other rocks for radioactive analysis.

Collection in the northwest portion of the state has had the cooperation of the Department of Geology, Emory University. Mr. R. J. Martin visited a number of sites, not all adjacent to the departmental field station at Ringgold, to collect material for our study.

Other portions of northwest Georgia are represented, although the samples may not have been examined by date of publication. The formations best represented are the Fort Payne chert and associated sandstones. A few scattered samples have been taken from other formations.

COASTAL PLAIN: More of the coastal plain samples have been taken from the Atlantic coastal than from any other part. We know depth below surface as well as stratigraphic horizon. Some were collected at ground surface; others, from depths of 3, 6, 9 or 12 feet.

Even Atlantic coastal plain sampling has not been random, because we depended upon others to collect material. Nevertheless, for the area between the Savannah River and the St. Marys, the coverage is good.

HIGHLANDS: Practically all granite has come from the Highlands. Through the courtesy of producers of other rock than granite, we have secured several dozen from near Warm Springs and Pine Mountain, from the gold belt, and from Wilkes and Talliaferro counties.

When all samples previously requested have been received, we plan to initiate our own program. This will cover, systematically, those portions of the state that are not represented in gifts.

#### selection and preparation

Where only a few samples are available from any one area, all have been or will be counted. If, however, a large number are on hand, a random sampling of those collected has been or will be used.

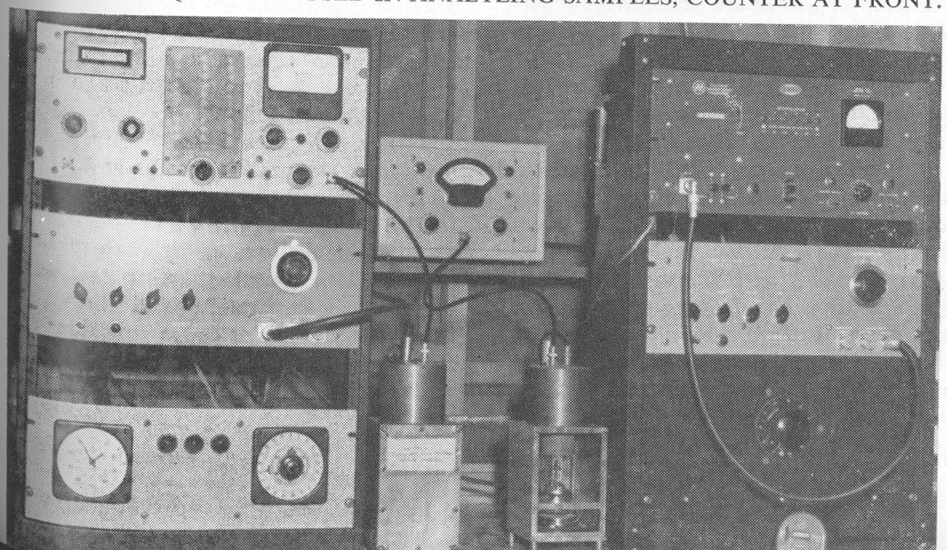
The hard rock samples (granite, marble, sedimentary rocks, etc.) are prepared for counting by crushing to 80 mesh, with a hand-driven mortar and pestle. Coastal Plain sand samples are prepared first by removing the organic matter, then washing, and crushing to 80 mesh.

#### instrumentation

The samples are counted with two nearly identical scintillation counting systems which are sensitive only to alpha radiation. The equipment in each system consists of a counting chamber, preamplifier, pulse amplifier, discriminator, scaler, and timer (Fig. 1). The equipment is commercially available with the exception of the preamplifier and counting chambers, which were designed and built here. The counting chamber is of the type described by Reed (1950).

The counting chamber is made of brass plates and only silver solder is used for joints. Situated inside each chamber are a stainless-steel sample dish, a scintillator screen, and a Dumont G6292 photomultiplier tube. The sample dish has a 1/8″ x 2″ cylindrical cavity which contains the sample, the alpha activity of which is being measured. Scintillator screen consists of a thin, uniform layer of zinc-cadmium-sulfide powder (Patterson Type B) adhering to a circular piece of scotch tape which is supported by a

FIGURE 1 — EQUIPMENT USED IN ANALYZING SAMPLES, COUNTER AT FRONT.



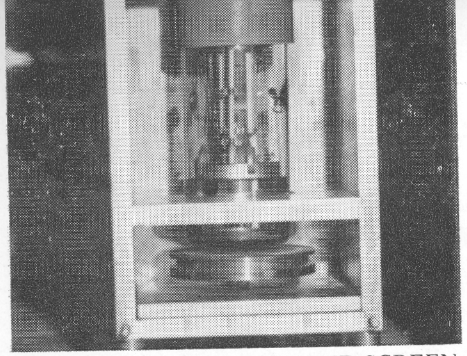


FIGURE 2.-SAMPLE DISH AND SCREEN

stainless-steel ring. The screen, the active diameter of which is 2¼″, is maintained at a fixed distance (⅛″) above the level of the sample.

Preparatory to counting, the sample is placed in the sample dish, the scintillation screen positioned, the dish and screen assembly placed in the chamber (Fig. 2), and the light-tight door clamped in place. Alpha particles, emitted by the radioactive elements contained in the sample, strike the ZnS screen and produce scintillations. The photomultiplier tube, situated directly above the screen (Fig. 2), detects the scintillations and produces an electrical pulse on each counting event. The pulses are amplified and passed through a discriminator which is adjusted to pass the large pulses produced by alpha particles and reject the smaller pulses produced by beta and gamma radiation. Output pulses from the discriminator pass to the scaler, which totals the number of pulses occurring in a given time. The counting data are converted to percentage of U and Th by using graphs plotted from standard samples.

Background count can be defined as the number of counts produced by anything other than the sample. These counts may be produced by electrical noise and by radiation coming from any source except the sample itself. Freedom from electrical noise is achieved by electrical shielding and filtering. Design of the counting chamber to provide the maximum internal shielding, careful choice of materials used in construction of the apparatus, and painstaking decontamination of the apparatus allow a low-alpha background to be achieved. The photo tube voltage and the discriminator level are adjusted to provide complete discrimination against beta and gamma radiation. (The high voltage power supply is operated at + 900 volts.) The scintillation screen is replaced whenever a background count of more than five per hour is observed. A background count is made by placing the screen on a clean piece of bond paper in the sample chamber and observing resulting count. The background normally is between two and five counts per hour.

The equipment has been in use for over a year. Periodic spot checks of previously run samples show that both sets of equipment will reproduce the original counts very faithfully. Also, a polonium-210 alpha calibration source is used as a standard for checking the performance of the equipment. Beta and gamma sources are periodically inserted in the sample chamber to insure that the discriminator is set properly. From the foregoing discussion, it is obvious that only the gross alpha activity is determined in our measurements. This suffices if precise knowledge of the separate uranium and thorium contents of the samples is not required, since the world-wide average of the thorium-uranium ratio is known for the minerals of interest to us.

For particularly interesting samples, however, it will be desirable to make separate determinations of the uranium and thorium contents. The technique to be used will involve a radio-chemical separation of the two elements and may be described as follows.

The rock, ground to 80 mesh or smaller in preparation for the separation of uranium and thorium, is leached with acid. The radioactivity of the acid solution is then determined by dip counting or scintillation well counting methods. The actual separation will then be achieved by the selective sorption of anionic uranium nitrate or chloride complexes on strong base anion exchangers. The effluent solution will be counted as before and the difference in radioactivity will indicate the concentrations of uranium and thorium in the sample. The uranium can then be washed from the column with distilled water or a slightly acid solution.

## biologic and geologic significance

Although all granite contains some radioactive elements, preCambrian granites have a larger proportion than those of later geologic age. This conclusion is amply supported by analysis from all of the granite areas so far published.

Current ideas on the genesis of granite pose the question of whether or not all have the same origin. Older granites may have differentiated from primoidal magmatic mixtures to form the early crust, as exemplified in the great shield areas. Other may have arisen through palingenetic fusion in deforming geosynclines, finally resting in linearly extended orogenic belts. This would involve a systematic and progressive difference in composition of palingenetic granites from earlier to later times. There is some evidence of an arrangement of this kind.

Under this latter hypothesis, a geochemical cycle offers a useful concept in following the course of a specific element through different stages. Certain substances, such as Cr, Ni, Co, native Cu, most hypothermal gold lodes, not to mention pitchblende and magnetite, came to the earth's crust during preCambrian volcanism. The rare-earth elements, such as Y, Yb, Li, Be, Cs, Ba, Ta, and Pb, tend to increase progressively in younger granites.

Given a wide distribution of granites of known geological age, it may be possible to determine progressive and systematic change in radioactive elements and/or minerals. If done on a quantitative basis, it may be possible to predict those granitic areas and/or ages most likely to be of utility in securing desirable sources of energy.

If the position of radioactive elements and/or minerals may be given its true perspective in time and space, pure science may be advanced along many fronts. A knowledge of temporal and spacial distribution of radioactive elements and minerals is basic to studies of the thermal history of the earth. If, as many are constrained to think, radioactive heat is the source of the energy for diastrophism, it may be possible to predict on this basis. Again, the cause of earth movements may be advanced another step toward solution. Even the age of the earth and the universe, in which it finds itself, may be linked with the time sequence of radioactive elements and/or minerals.

BIOLOGICAL EFFECTS: If biological mutation is stimulated by strong radiation, another avenue of research is open. Giant upwellings of granitic rocks, with the accompanying increase in radioactive waters, may be responsible for the wholesale destruction of senile life forms, thus promoting rapid and disordered change in genera and species. Magmatic springs, some of which are radioactive today, may have influenced organic environment to an unknown extent. Certainly, the Miocene (Tertiary) outporings of granitic composition in western North America and the accompanying wide distribution of volcanic ash coincided with enhanced mammalian mutation. If such a time relationship may be established for each of the great periods of organic change, it poses a problem of extreme scientific interest, especially in relation to man-made nuclear explosions and radioactive fall out.

ECONOMIC ASPECTS: If, as Brown (1955) suggests, low-grade radioactive rocks possess sufficiently utilizable nuclear energy to replace currently used fuels, it behooves man to examine potential reserves. The State of Georgia presently shows few such concentrations. When the present study has been completed, more will have been uncovered. Detailed investigation may then be initiated with a view toward eventual utilization of those proven to be of sufficiently high content.

# edited in retrospect

the
year
of
progress

• It is doubtful that in its 10-year history, *The Research Engineer* can boast of a more popular issue than the one of January, 1956. This issue, devoted to the initial report of the Georgia Tech Nuclear Science Committee, drew many requests from all over the world, and our supply was depleted within a month of publication.

The requests are still coming in, so we thought that it might be wise to devote this issue to a progress report of Georgia Tech's nuclear program. A quick reading of this issue should convince you that this is a report of which every alumnus and friend of Georgia Tech should be proud. In its pages is recorded the rapid progress that Tech administrators and faculty members, with the interested aid of Governor Marvin Griffin and the Board of Regents, have made in this new and challenging field in just twelve short months.

The master's level program in nuclear engineering and nuclear science that was in the planning stage last year at this time is now a reality as the first students entered the program in September.

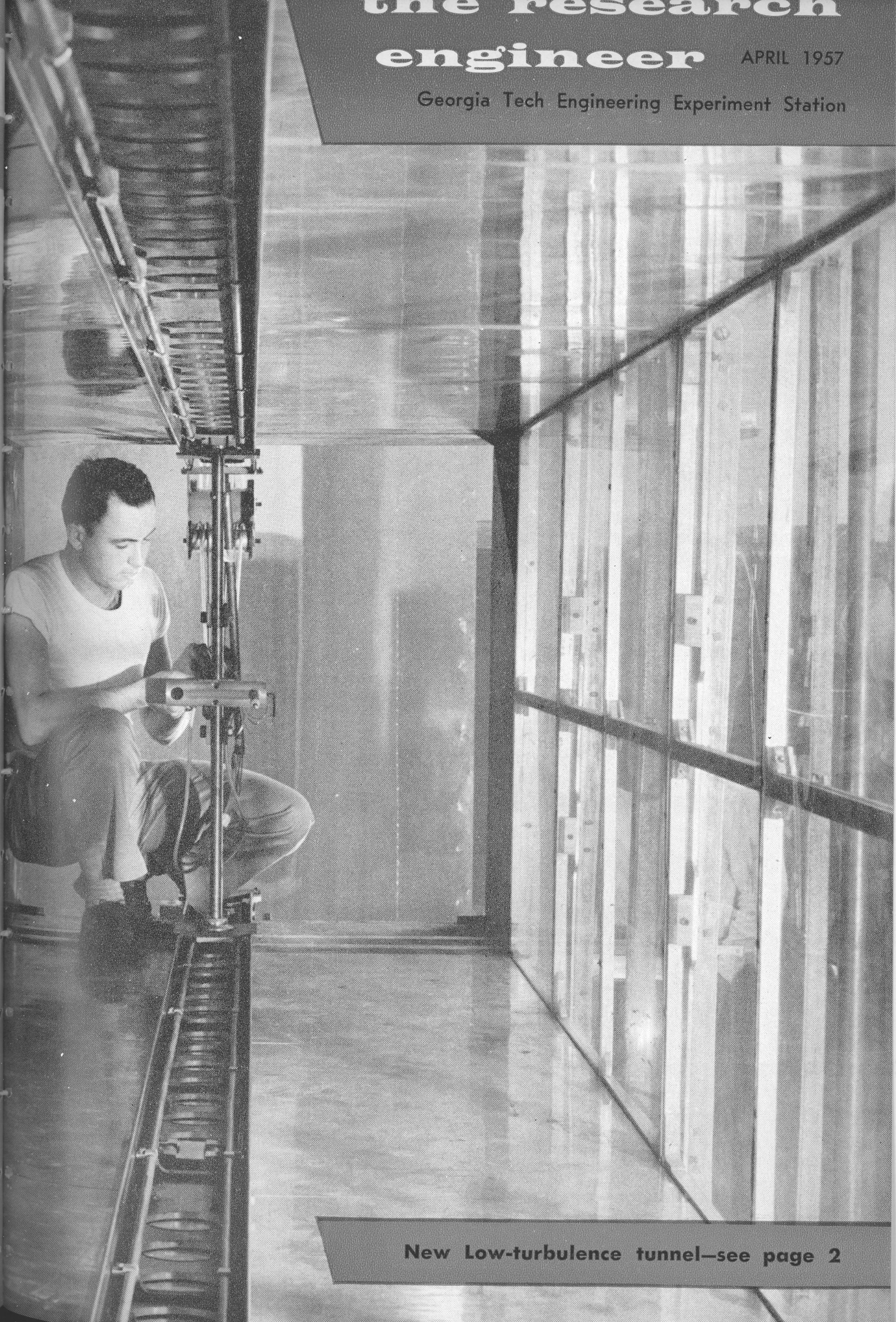
The radioisotopes laboratory building that was established in last January's issue as the number two need of Tech's program is now in the hands of an architect and should be completed sometime this year. This building and its equipment were made possible by a special $300,000 grant from Governor Griffin this past April.

A subcritical assembly, a valuable educational and training tool, is now nearing completion and uranium and source material to make it operate have been promised Tech by the Atomic Energy Commission.

Progress has been made in the Tech request for a research reactor during the year and Governor Griffin and other State officials have shown interest in this phase of Tech's problems.

All in all, Tech has come a long way in this field in the past year. It is our hope that the coming year will be as fruitful in this and other fields of engineering and scientific education.

the research engineer APRIL 1957
Georgia Tech Engineering Experiment Station



New Low-turbulence tunnel—see page 2