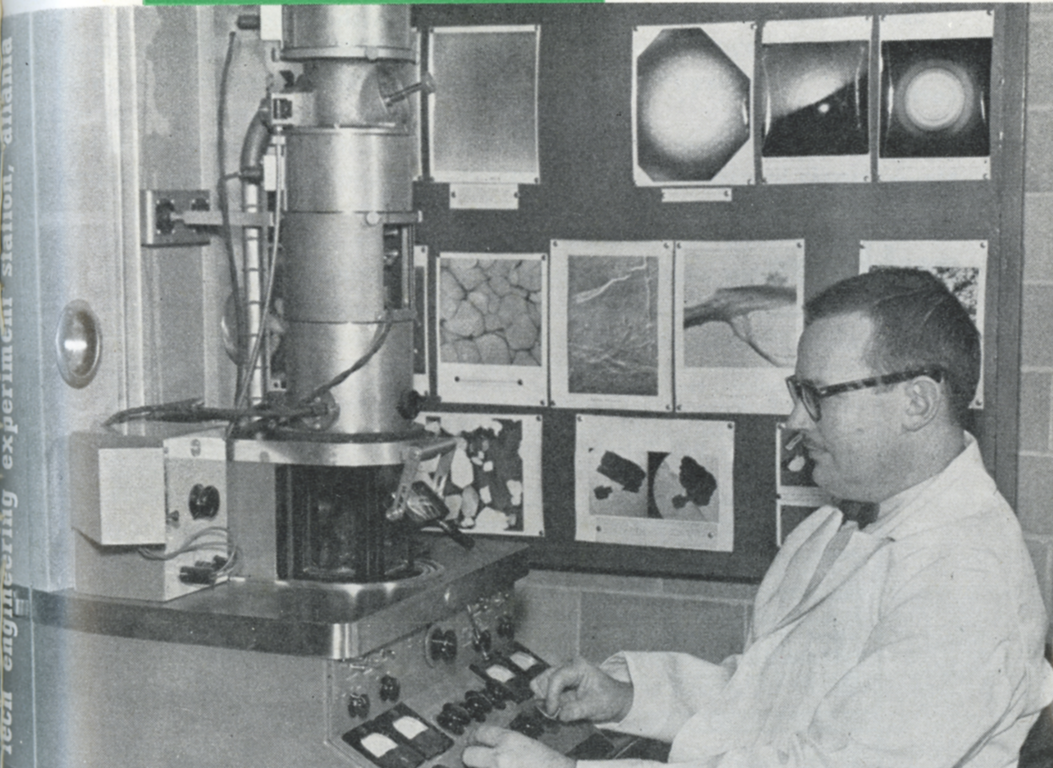
the research engineer

april 1955



electron diffraction

contents

cover

Research Physicist LeRoy A. Woodward is shown in the cover photo operating the Station's electron microscope as an electron diffraction camera. Specimens of pictures thus produced are the three directly above his head.

dear reader—

You soon will receive a letter asking if you wish to continue to get The Research Engineer. Your cooperation in returning the questionnaire promptly will be appreciated. We can make the magazine serve your needs better if we know that you are interested.

authors

Edwin J. Scheibner holds the B.S. in Physics from Georgia Tech, 1950, and the M.S. and Ph.D. from Illinois Institute of Technology. He has worked at the Georgia Tech Engineering Experiment Station, the Institute for the Study of Metals, University of Chicago and at IIT and is now in research at the Bell Telephone Laboratories, Murray Hill, New Jersey.

John L. Brown, Assistant Research Physicist, holds the B.S. in Physics from Georgia Tech, 1950, and is working on the M.S. After extensive experience with an optical firm, he came in 1950 to the Station's optics laboratory, where his research interests include electron and optical microscopy, electron diffraction and ultrasonics. His hobbies include astronomy and sound reproduction.

J. M. DallaValle, Professor of Chemical Engineering and Research Associate, holds three degrees from Harvard: B.S., 1927, M.S., 1928 and Sc.D., 1930. He has served industry and government, including the U. S. Public Health Service, 1933-41. He is an authority on *Micromeritics* and *The Industrial Environment* (the titles of his two books).

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Electron Diffraction in Metallurgical Research

EDWIN J. SCHEIBNER* and
JOHN L. BROWN, Assistant Research Physicist

C. J. Davisson and L. H. Germer, of the Bell Telephone Laboratories, between 1925 and 1927 conducted a series of classic experiments on the reflection of electrons from a single crystal surface. They made an historic observation of the wave nature of electrons, confirming a basic postulate of wave mechanics—that moving material particles have wave properties, a theory upon which rests much of the physicist's understanding today of fundamental particles and the structure of atoms. Earlier, Louis de Broglie, of Paris, had demonstrated that electrons traveling with a speed corresponding to energies of a few hundred electron volts have a wavelength in the x-ray region. This suggested to Davisson and Germer that such electrons might be reflected from crystals in the same manner as x-rays. They experimented for months and finally discovered that the electron is a wave as well as a particle, an apparent paradox, but actually a vital part of the foundation of modern physics. This discovery provides the basis for the development of electron diffraction into an extremely useful tool in present-day research. As metals normally are aggregations of tiny crystals turned every conceivable way, electron diffraction is more than ordinarily valuable in metallurgical research.

G. P. Thomson (now Sir George Thomson), of England, was the first person to expose a photographic plate to a beam of electrons passed through a very thin sheet of metal comprised of many crystals. This photographic plate when developed

*Present address: Bell Telephone Laboratories, Murray Hill, New Jersey.

shows a pattern of concentric rings characteristic of randomly oriented crystallites and is known as an electron diffraction pattern. That discovery confirmed the opinion that electrons are a particle-wave combination.

For coincidentally making their discoveries, Davisson and Thomson in 1937 were awarded the Nobel Prize in Physics.

Electron and X-ray Diffraction

Although the early diffraction experiments were performed with electron energies which gave wave lengths in the x-ray region, modern electron diffraction equipment is operated at voltages of approximately 50 thousand volts which give a wavelength of .05 Angstroms, considerably shorter than x-ray wavelengths. Because of the short electron wavelengths the diffraction angles are small and, therefore, the following approximation may be made:

$$2 \sin \theta \sim 2\theta \sim \tan 2\theta = \frac{R}{D}$$

where R is the measured radius of a ring in a polycrystalline ring pattern and D is the effective distance from the specimen to the photographic plate. The Bragg relation then becomes

$$\lambda = 2d_{hkl} \sin \theta \sim \frac{d_{hkl} R}{D}$$

or

$$\lambda D = d_{hkl} R.$$

The microscope constant (λD), the product of the electron wavelength and specimen-to-plate distance, can be determined by measuring the radii of the rings of a pattern from a known standard substance.

Another consequence of the short electron wavelength is that single crystal patterns are in effect a representation of a plane section through reciprocal space. Consider the Ewald construction in reciprocal space as shown in Figure 1. A vector of length, $1/\lambda$, terminating at the origin of the reciprocal lattice is drawn along the incident direction. The Ewald sphere is then constructed with A as its center and $1/\lambda$ as the radius. The intersection of the Ewald sphere with a reciprocal lattice point indicates an allowed reflection, and AB is then the direction of a diffracted ray. This construction is equivalent to the usual Bragg relation because of the properties of the reciprocal lattice. The direction OB is perpendicular to the set of planes (hkl) which are represented by the point B, and the distance OB is proportional to the reciprocal of the interplanar spacing. Referring to the figure we have

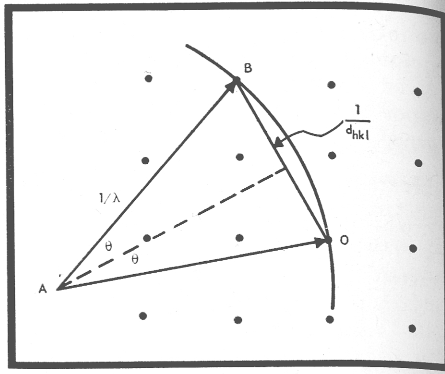


Figure 1. The Ewald construction in reciprocal space (as described in the text).

$$\sin \theta = \frac{\frac{1}{2d_{hkl}}}{\frac{1}{\lambda}}$$

or

$$\lambda = 2d_{hkl} \sin \theta.$$

In the electron case the radius of the Ewald sphere becomes very large compared to the reciprocal lattice spacing, and thus the Ewald sphere is essentially a plane, and the resulting electron diffraction pattern is just proportional to a section through reciprocal space. Similar results can be obtained by x-ray diffraction only by use of the precession camera.

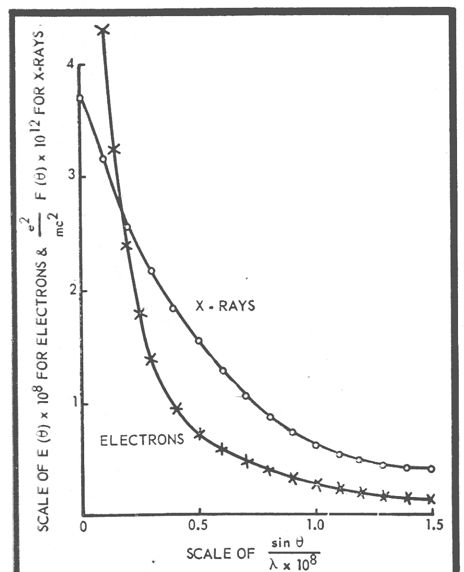
Electron wavelengths depend only on the value of the accelerating voltage used and, if the voltages are well-regulated, will be essentially monochromatic. X-rays, however, contain both general and characteristic radiation. Characteristic radiation is dependent upon the target material. Thus, when it is necessary to restrict the band of wavelengths used, one has to resort to the use of filters or crystal monochromators. Electron diffraction equipment requires that the specimen be placed in a vacuum, a limitation which is not serious, as far as metals are concerned.

Electron and X-ray Penetration

Perhaps the most significant difference between electron diffraction and x-ray diffraction is the low penetrating power of electrons as compared to x-rays. This results from the fact that electrons are affected by the nucleus as well as the atomic electrons. The atomic scattering factors for electrons and x-rays for aluminum are compared in Figure 2.

Since electrons are scattered easily their penetrating power is low as compared to x-rays, and, therefore, bulk specimens may be examined only by reflection from a surface. This limitation of the electron diffraction method is, paradoxically, its greatest advantage, since it enables us to obtain information about surface layers which are too thin to contribute appreciably to the normal x-ray diffraction pattern. The preparation of transmission specimens is essentially the same as for electron microscopy except that better results sometimes are obtained with slightly thicker specimens; even so, transmission specimens for electron diffraction must be thin.

Figure 2. The atomic scattering factors for electrons and X-rays (for aluminum).



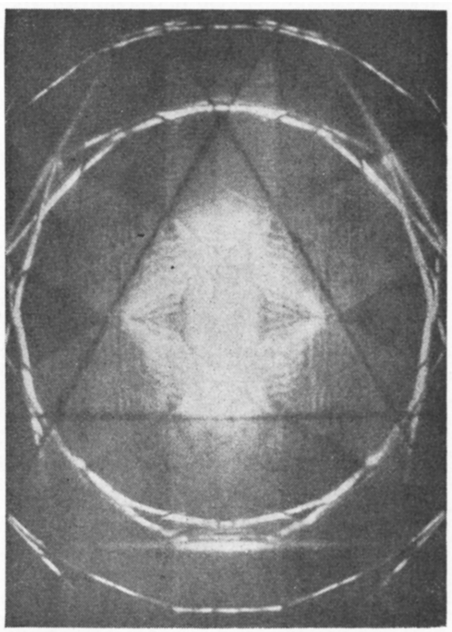
The electron diffraction method is useful in attacking metallurgical problems which can be studied through examination of the surface of bulk specimens. Examples are oxidation, corrosion, nitriding, absorption and diffusion problems. It is also used in conjunction with the usual x-ray method for investigation of the study of the behavior of thin metal films.

Figure 3 is an unusual electron diffraction pattern of a thin sheet of mica, taken with a wide-angle electron beam. The wide angle was used to allow a great range of incident directions, the result being a multiple interference pattern which well illustrates the wave nature of the electron. Ordinarily, such a complex pattern is not obtained, since the divergence of the electron beam is restricted to very small angles; however, the pairs of dark and light lines forming the triangular and circular type figures are commonly observed. These lines, called "Kikuchi lines" after the Japanese scientist who first observed them, are an indication of the degree of perfection of the specimen crystal because even though the electrons are scattered in two different parts of the crystal, the lines are still sharp. Ordinarily incoherent scattering of the electrons as they pass through a specimen gives a Gaussian-type intensity distribution with angle. If the specimen is a single crystal, two values of the scattering angle satisfy the Bragg condition for a particular set of planes; electrons which normally would go to the large angle (θ_2 in Figure 4) are scattered coherently and appear at the smaller angle θ_1, while those which would have appeared at angle θ_1 are scattered and thus appear at θ_2. Since the intensity distribution decreases with angle, the net effect is that a deficiency of electrons results at θ_1 and an excess of electrons at θ_2. Pairs of light and dark lines are formed thus by various sets of planes in the crystal. As distortion is introduced into the crystal lattice it becomes more difficult for electrons at θ_1

to scatter exactly to Θ_2 and for those at Θ_2 to scatter exactly to Θ_1 so that the Kikuchi lines broaden until they finally disappear altogether. Thus they provide a sensitive method for detecting minute amounts of distortion. Heidenreich and Shockley at Bell Telephone Laboratories have studied the mechanism of slip in aluminum single crystals and have shown that distortions of about 5 percent are sufficient to cause disappearance of Kikuchi lines. In their work they are also able to show by analysis of the electron diffraction patterns that the slip process is not one of simple translation alone but that some rotation also takes place in the slip plane. Combined with electron microscope studies of replicas taken from the surface of the slipped crystal, their work gives a clear insight into one of the more fundamental processes in physical metallurgy.

One of the most direct applications of the electron diffraction method is to the identification of intermediate phases which exist in such small amounts that they cannot be detected by other means. When one etches the material selectively,

Figure 3. A wide-angle beam electron diffraction pattern of a thin sheet of mica.



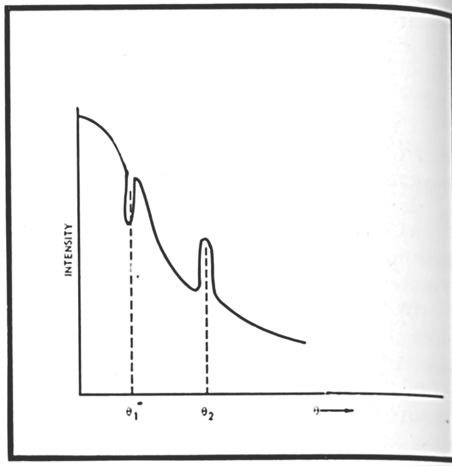


Figure 4. Here the electron density is shown as a function of the scattering angle.

so that the matrix is etched at a greater rate than the intermediate phase, this phase is left in relief as shown in cross-section in Figure 5. An electron microscope study of surface replicas should be conducted concurrently, to supplement the electron diffraction results with information on the size and distribution of intermediate phase regions.

Precipitation Studies

The precipitation from solid solution might be studied further by utilizing the electron diffraction method. It is well known that the process of precipitation hardening involves a precipitation of the excess component from a supersaturated solid solution and an increase in the particle size of the precipitate. In the supersaturated state, an alloy is mechanically soft; it becomes harder as precipitation proceeds, but if the particle size of the precipitate becomes too large, the alloy is over-aged and begins to resoften. If the precipitate particles are visible under an optical microscope, the alloy is generally over-aged, thus it is desirable to use methods which reflect the earlier stages of precipitation. At maximum hardness, the size of precipitate particles is still too small to give sharp x-ray diffraction reflections. It is possible that a combined application of electron diffraction and

electron microscopy will give more direct information on the growth and orientation of precipitate particles than any other present-day method.

A replication method has been devised recently which removes and retains precipitate particles of the alloy. The steps of the method are outlined below:

(a) Selective etching to bring precipitate particles into relief, as shown in Figure 6 (a).

(b) Formation of plastic film on the surface for the replica, as shown in Figure 6 (b).

(c) Etching through plastic film.

(d) Removal of replica.

The result is a replica which shows the distribution of the precipitate particles in the matrix since they retain their orientation during the replication process. The identification and orientation of the particles can be done by using a new feature of the RCA electron microscope called a selected area diffraction unit. This unit enables one to take an electron micrograph and an electron diffraction pattern from the same portion of the replica without moving the specimen.

Thin Metal Films

A simpler application of electron diffraction to metallurgy is in the study of thin metal films. Many things can be learned about the behavior of metals when they are studied in the form of thin films. These films can be deposited upon collodion for transmission or reflection studies and upon glass for reflection studies alone. Changes such as grain growth, crystallite orientation and oxidation, which take place during the heating of these films, can readily be determined. Comparisons of transmission and reflection studies of the same film will reveal any structure changes through the thickness of the film. Sometimes the orientation and crystalline structure at the base of a film will be markedly influenced by the substrate structure.

Thin films provide another means of studying the alloying of metals. Dual-layer films of two different metals in varying proportions may be heated and the

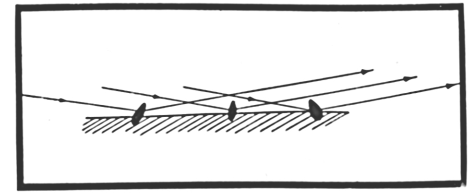


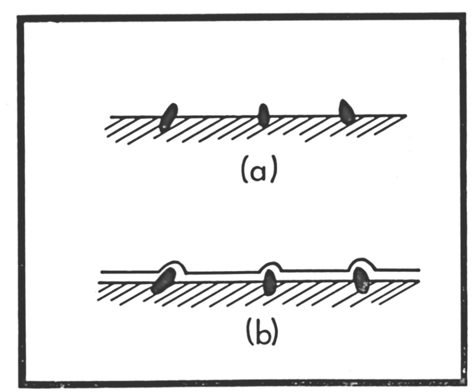
Figure 5. The paths of electron beams diffracted from a selectively etched surface.

resultant alloying studied. If the films are prepared in such a manner that the overlaying film is smaller in area, boundary conditions and intergranular penetration can be observed. Here again the selected area diffraction unit proves useful in differentiating various phases that may exist at the boundary.

Conclusion

X-ray diffraction is universally appreciated by physicists for its contributions to our knowledge of atomic, molecular and crystalline structures. Today, the newer field of electron diffraction is taking its place beside the older. Especially in metallurgical research, we are finding electron diffraction increasingly valuable because of the development of special techniques. Certain metallurgical problems formerly relegated to x-ray diffraction are now solved more easily by electron diffraction. The method is truly proving its worth in expanding our knowledge of metallic structure.

Figure 6. Here are the first two steps in the new replication method (see text).



the computer center

DR. EUGENE K. RITTER, an authority on applied mathematics and computers, in early February was appointed Director of the Rich Electronic Computer Center, the Station's new $1 million laboratory.

Dr. Ritter came to Georgia Tech from the directorship of the Computation and Ballistics Department, U. S. Naval Proving Ground, Dahlgren, Virginia. There he had responsibility for the theoretical and experimental work in the ballistics of the Navy's projectiles, bombs, mines and rockets; research in many branches of applied mathematics and mathematical physics; and planning, operation and maintenance of the Bureau of Ordnance's large-scale digital computation laboratory. His facilities included the famous MARK II and MARK III, both constructed by Harvard, and the NORC (Naval Ordnance Research Calculator), built, under his supervision, expressly for the laboratory by IBM. He had been Director of that laboratory since 1952.

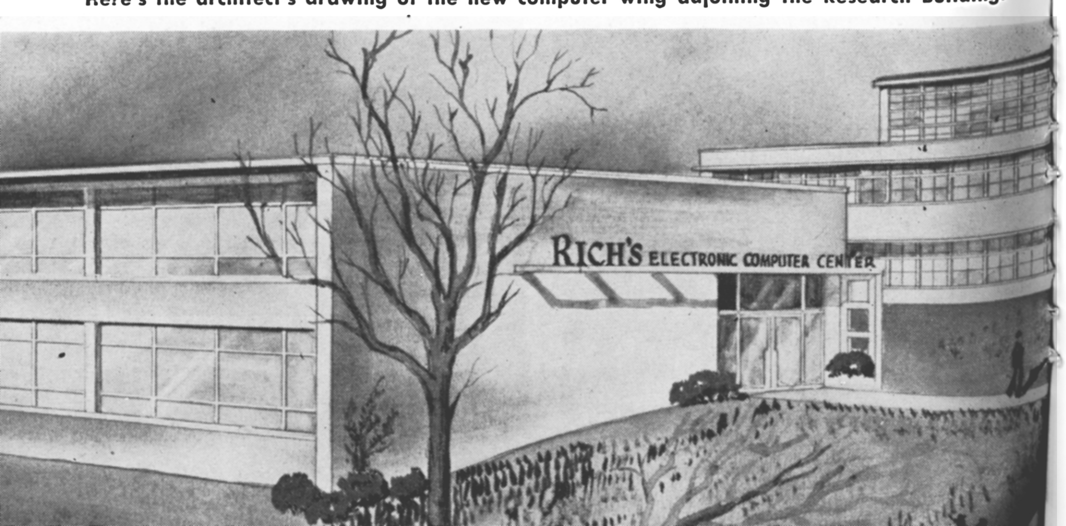
The new director is the author of a textbook on a phase of ballistics and of a number of scientific articles on mathematics and computation.

Dr. Ritter

Dr. Ritter is a native of Virginia. He received the B.A., 1930, in mathematics, physics and English from the University of Richmond; and the M.A., 1934, and the Ph.D., 1949, both in mathematics and both from the University of Virginia. He also has taken graduate studies at the University of Pennsylvania.

Prior to World War II Dr. Ritter taught mathematics at The Citadel and the Universities of Virginia, Pennsylvania and Richmond. As a Reserve officer in the Navy he served on the ordnance engineering staff of the U. S. Naval Postgraduate School at Annapolis, 1942-46. He remained there, as Assistant and Associate Professor of Mathematics and Mechanics, 1946-49. He was Head of the Simulation and Computation Department and Lecturer in Applied Mathematics at the University of Michigan's Engineering Research Institute, Willow Run Research Center, 1949-52.

Here's the architect's drawing of the new computer wing adjoining the Research Building.



the president's page

OPERATIONS RESEARCH is a new concept in management which uses the scientific method usually associated with physics, engineering and mathematics in the solution of purely business problems. As its name implies, it is research on operations, but a particular view of operations and a particular kind of research.

The new field originated during World War II in England, when the British Government asked a group of scientists to work on such problems as deploying planes to hunt for enemy submarines and determining ship routes to minimize the probability of loss due to enemy torpedoing.

Operational research (as it came to be known in England) worked seeming miracles for the military. After the war a few of the better managed companies there and in the United States experimented with the application of its scientific and mathematical methods to business operations. In their experience, the scientific attitude and its associated techniques, the distinguishing features of operations research, could be applied to many kinds of business operations. Today, in business and government, operations research is widely accepted.

The Georgia Tech Engineering Experiment Station and the School of Industrial Engineering are developing a competent operations research group, and an example of their work is reported in the new bulletin "Industrial Engineering and Economic Studies of Peanut Marketing," reviewed elsewhere in this issue. This study is operations research because it is an analysis of operational problems, together with presentation of data in a form which enables management in the peanut processing industry to decide for itself whether or not to utilize the recommended methods.

Operations research is imaginative research. While it is not inherently a decision-making function, it provides a service to high-level executives, giving them a rational basis for making policy on problems of a very complex nature.

With a number of other substantial achievements already to its credit, the Engineering Experiment Station's operations research group is now undertaking a study of the ways in which this new field can be of greater service to industrial Georgia and the Southeast. This survey involves gathering information from various sources and analyzing it in what might be called, "operations research *on* operations research." At the same time, the School of Industrial Engineering is offering a course and conducting a seminar on the subject – a good example of the way the components of Georgia Tech balance research and education.

The Rich Electronic Computer Center, which will be functioning later this year, will enable the Engineering Experiment Station to undertake even more complex problems in this field.

As industrial operations in the South expand and develop, more and more Southern industrialists will turn to operations research. In it, they will find a new group of specialists – scholars, applied mathematicians, scientists, engineers, economists, others – all with imagination, skill and a fresh point of view. The balancing of business' responsibilities to society, consumers, owners and employees will continue to be the fundamental task of executives. Operations research can help them to make those decisions more intelligently.

President, Georgia Institute of Technology

EESential Information

ENGINEERING EXPERIMENT STATION

GEORGIA INSTITUTE OF TECHNOLOGY

EVERY TWO WEEKS, for more than a year now, the employees of the Engineering Experiment Station have been publishing a semi-monthly newsletter EESENTIAL INFORMATION. Here are some typical items of news from recent issues.

A SIX-FOLD INCREASE in state support for the Engineering Experiment Station recently was advocated in a letter from the Board of Regents of the University System of Georgia to members of the General Assembly. "The Engineering Experiment Station of Georgia Tech is now receiving a direct allocation of only $89,000 in state funds," they said. "As a result, most of the activities of the Station are concerned with contract research for federal agencies and private industrial concerns [amounting to approximately $2 million a year]. Research that will be beneficial to the people of the state as a whole is very limited. The board believes that the annual state appropriation for the important function of engineering and industrial research should be at least $575,000 per year, an increase of $486,000."

DR. ROBERT S. INGOLS, Research Professor, has been awarded a National Science Foundation grant of $7,100 for a project entitled "Protein Changes with Chlorine."

H. H. SINEATH, *Assistant to the Director, has been installed vice-chairman of the Atlanta Section, American Institute of Chemical Engineers.*

A RUSSIAN STEAM TABLE, one of perhaps fewer than two dozen outside the Iron Curtain, has come into the Station's possession.

ALL 185 EES-ERS recently chest x-rayed by the Fulton County Health Department (incidentally with a portable x-ray unit originally developed here in 1947) were found to be free of tuberculosis. Although more than 1 million other Georgians have been x-rayed with this unit and its prototypes, this was the first time chest x-ray service had been offered the employees of the Station.

JOHN JAY HOPKINS, *chairman and president of General Dynamics Corp., builder of the submarine* Nautilus, *will deliver the commencement address at Georgia Tech graduation exercises June 13.*

DR. J. M. DALLAVALLE has been awarded a $4,000 grant by the Socony-Vacuum Oil Co. of N. J. in support of a research project entitled "The Diffusion of Gases Into and Out of Micropores of Certain Catalysts."

ENGINEERS' WEEK, *the last week in February, was celebrated by Station Open Houses for 50 outstanding high school seniors from all over Georgia, for Station employees and their families and Georgia Tech students.*

THREE GEORGIA TECH staff members recently have become licensed professional engineers in Georgia. They are Maurice W. Long, Special Research Engineer; Marion R. Carstens, Associate Professor of Civil Engineering; and Demetrios A. Polychrone, Associate Professor of Architecture.

The Italian University: Some Observations

J. M. DALLAVALLE, Professor of Chemical Engineering and Research Associate

THE ITALIAN UNIVERSITY is among the oldest in the world. In many ways, it still possesses much of its antiquity, though the architecture of its newer buildings somewhat detracts from the dignity it once possessed. Except in the fields of engineering and medicine, the system of instruction and most of the customs are still preserved virtually intact. If one were asked for a precise difference between American and Italian university practices, he might say that liberalism is more pronounced in the latter. Yet, the average Italian student would not agree. He is much worried by the changes in teaching techniques and by delegated responsibilities without realizing that these are attributes of the American system of higher education. The changes were necessary, and in Italy, as in America, they were brought on by larger enrollments, greater costs of education and perhaps by recognition of technological necessities to survive with others in this modern world.

The Liberal Arts Student

The average student of a liberal arts college in Italy does pretty much as he pleases. His performance is not gauged by attendance or homework. The final examination is the only thing by which his competence is measured. To be called on for a recitation in class is an unheard-of experience. In fact, if a teacher asked one question of a student, the class would interpret it as an accident. If the teacher made the same mistake again – and asked another student another question – the class would interpret this as con-

*Dr. DallaValle was a Fulbright Professor at the University of Milan during the academic year 1953-54. "The University" of which he writes, however, is a composite of Milan and a number of other Italian universities visited.

stituting a habit and would resent it. Finally, if the teacher failed to comprehend the class' resentment and asked still a third question, it is conceivable that the entire class would walk out on him! Extreme as it might seem to Americans, a general strike of the student body, resulting from a few questions in class, is not out of the realm of possibility. This depth of feeling and independence of action lead me to say flatly that the Italian university is without parallel and is almost too undisciplined and illogical to be comprehended by an American visiting professor.

A teacher of liberal arts may have as many as 200 students enrolled in his class. Yet, he would consider himself enormously successful if after the first meeting more than 20 students attended class. This is true because Italian students are notorious bookworms, i.e., they depend on books and not on lectures. Classes are considered only as devices to point the

Milan's *Galleria*, which is a famous arcade housing many offices and small shops.

way to learning. Thus, rather than all being present at all lectures, students depend on a sort of rotational attendance. They freely exchange class notes and even duplicate lectures to keep the nonattenders abreast.

There are both good and evil in these practices. However, since the Italian university is now going through a transition, it would be unfair to generalize. It must be remembered that historically in Europe the attitude toward higher education is much different from ours. The student body in Italy is more select; students in the Italian university are more serious and responsible than our students. They are, in a sense, more mature.

The Science Student

In Italy today — as perhaps everywhere else since World War II — a popular demand for higher education is becoming increasingly insistent. Thus, the Italian university is overcrowded and, since in most cases it is financed by the government, its costs are beginning to be burdensome to the taxpayer. The "mass" effect is telling, and though it is not yet widely recognized there, a sort of discipline in student-teacher relationships, much like what we have in America, is beginning to arise. The customs of many centuries cannot be overhauled quickly, however. The change is most noted in the sciences and especially in engineering and medicine. In these fields, in contrast to the liberal arts, class attendance is compulsory. It could hardly be otherwise when we consider that textbooks are unable to keep up with the rapid advances being made in engineering, medicine, science and technology. The fact that laboratory experience and research ability are essential to professional competence in these fields requires no arguments to induce attendance. Only in the liberal arts is the change coming slowly, and in this field, considering the temperament of Italian students, it might be better, if possible, to maintain the status quo!

The average Italian student is very much concerned about his future. Jobs are not plentiful, and if a student can afford higher education, he generally

strives to prepare himself for a profession. The four most important fields are engineering, law, medicine and teaching, both elementary and secondary. The demand for engineers in industry and government is almost as high as it is in the United States, but a surprisingly large number, especially civil engineers, go into private practice. Mechanical and chemical engineers almost wholly go into industry. Graduates in architecture enter private firms, and those in law and medicine enter either private practice or the overwhelming bureaucracy of government and socialized medicine. The latter is generally preferred by medical men, since they are permitted a considerable latitude to do private practice. Teaching positions are almost wholly on a competitive basis, since there are fewer positions than there are competent graduates.

Postgraduate work is increasing, but the equipment needed for carrying on advanced research is unavailable. Since my return, I frequently have been asked, how does our average undergraduate compare with his counterpart in the Italian university? This question is almost impossible to answer without qualifications. As stated before, university students in Italy are a more select group than the students in most American universities. The Italian student, by and large, has well defined ideas about what he wants to do after graduation. He has a better secondary education than that provided by most American high schools. He has a good foundation in mathematics, chemistry, physics and literature. The Italian student has had upwards of seven years of English and much more French and German than a graduate of an average American university. If he is scientific minded, he maintains his proficiency in mathematics, physics and chemistry, throughout his university sojourn. Any course in the university he wishes to take is open to him, and if he passes his final examinations, he receives credit for it. Only in engineering is dogmatism practiced to the extent that first courses come first — and even in engineering, the number of electives available would embarrass most engineering teachers in this country.

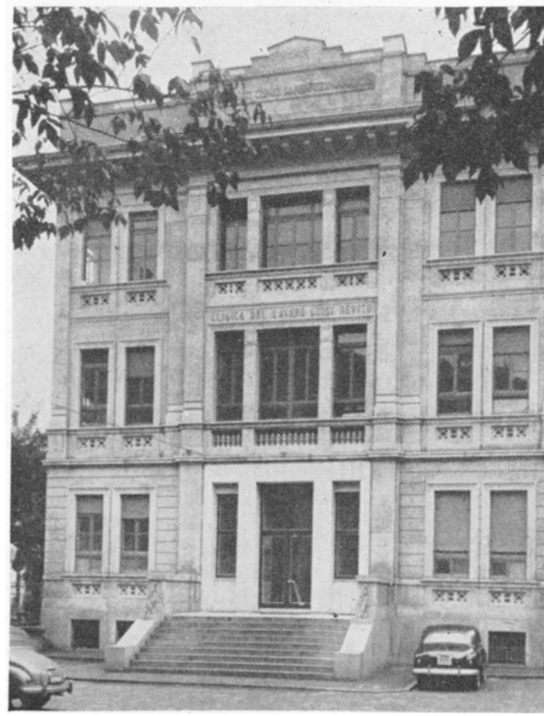
All this by no means implies that the Italian student is better than the American student. The proportion of those who "just want to get by" is as great as could be found in the average American university. The average American undergraduate is more competent in handling himself in critical situations, and he possesses practical know-how with engineering problems which would amaze the average Italian engineering professor.

Most Italian universities are co-educational, and women usually graduate with the highest grades in their classes. There is a surprisingly large number of women in the engineering and professional schools, and their competence is generally recognized. Female teachers are fast displacing male teachers in the secondary schools.

Social Life

There are in the Italian university no fraternities as we know them. Only one university provides dormitories, and these

The University of Milan's Medical School, where Dr. DallaValle taught half-time.

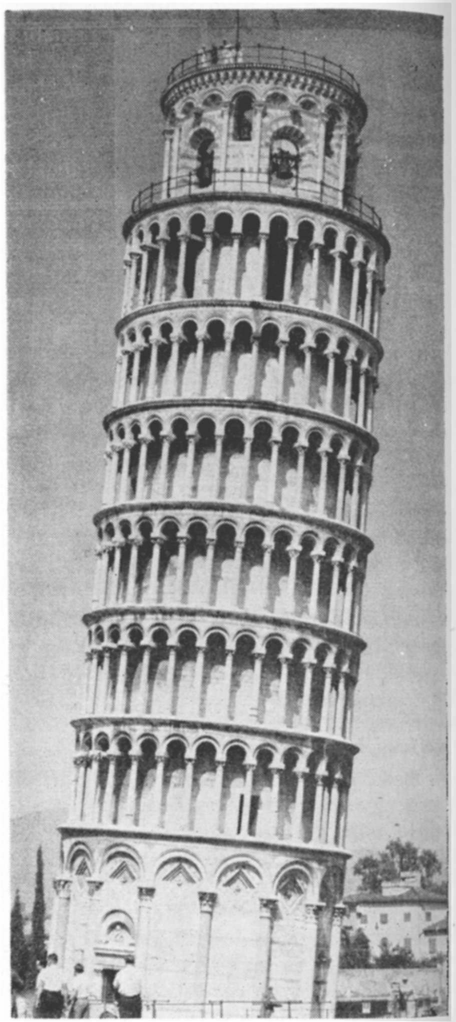


are woefully inadequate. Most students are daystudents, either residents of the city in which the university is located, or nonresidents who commute daily from homes up to 50 miles away. Those from areas without adequate commuting facilities board in private residences, predominately with relatives. One gets the impression that a student who came from any distance away and who was without relatives would be hard-put to find residence in a university center. Cities are very much overcrowded, and living in them is quite expensive.

Student Festivals

College life is not dull without fraternities, however, because there are numerous societies and informal groups. In fact, it is hard to keep up with student activities, many of which are conducted off-campus. Although there is no real liaison between societies and groups, somehow they come together as well as if they were coordinated. Custom has ordained that on special occasions students gather and perform, much as our students do on Homecoming Day. They wear medieval hats, long and sharply peaked in front, generally studded with small trinkets, and always made of the university's distinctive colors. Thus adorned, the students roam the city and surrounding provinces. Lower classmen are required to do certain stunts, usually in crowded centers, and otherwise perform ridiculously for the amusement of the upper classmen and passers-by. Drinking and hazing are not carried to the point of obnoxiousness, but the activities are intense while they last. Different as they might be in some important attitudes and aspects of behavior, the students of the Italian university are not completely indistinguishable from the students of an American university.

Italian students like sports very much. However, university teams, as we know them, are rare. The Italian student who is interested usually joins an off-campus "sports" club. Such clubs are subsidized by local merchants, and their membership in no way is identified with a particular university. Intercollegiate sports are unknown. The three major sports of interest are in order of importance: soccer, bicycling and basketball.



The famous leaning tower, near the University of Pisa, which the author visited.

The Teacher

No description of the Italian university would be complete without a discussion of the Italian professor. In his environment, he is, for the most part, extraordinary.

The title "Professor" is highly regarded. Almost every graduate of a recognized university in Italy is called "Doctor," but the title of "Professor" is reserved for the teacher of distinction or the professional man, especially the physician of outstanding reputation. If one should address a "Professor" as "Doctor," he would quickly be corrected. The average Italian is very fussy about his title, although the really outstanding individual would be modestly indifferent. Nonetheless, the title of "Doctor" is very much cheapened by its commonness.

Faculty Conditions

In general, the title "Professor" is conferred by the university in recognition of outstanding scholarship. Unfortunately, under the Fascists before World War II, the title fell into disrepute because it was given to so many only because of political or financial influence. Many an incompetent, with little to recommend him as teacher or researcher, gained the elite fraternity. Such a man might have sought the title to enhance his reputation or income. During the semester, his class might see him only once or twice, his lectures otherwise having been given by more competent assistants. Often he gained the prestigious title at the expense of his really competent and deserving colleagues. To the credit of the students, let me explain that they readily recognize the incompetent "Professor," and in fairness to the Italian university system and its many able professors, understand that the practice described is an exception, and it is fast diminishing.

One of the oddest things to be noted in many an Italian university is the lack of comradeship among the teaching staff. There is very little sociability, even within a specialty. Very often, two professors from different departments may have adjoining offices for years and yet hardly express a "good morning" to each other. In fact, one professor may not even know the name of the other professor who occupies the adjoining office. This situation is hard for an American to understand because there is no valid reason for it.

A great deal of jealousy and friction exist in many departments and between closely allied disciplines. For example, one cannot wander into an associate's laboratory for a friendly visit without first calling and receiving permission to do so. As likely as not, an assistant will answer the telephone, and if the request is made to him, he will reply that he has no authority to grant the request without consulting his superior. If the latter should answer, he may in fact, quite resent the request and ask for motives. Anyone who has some research under way is usually quite secretive about it. The attitude of the average researcher is usually defensive and rarely one of pride. Italian temperament seems to be geared to individualistic rather than team effort. Yet, when a piece of work is done, no attempt is too great to see that it is broadcast in the literature or in discussions before scientific societies.

The younger men are more aware of the need for teamwork in present-day research, especially in view of the fact that, more and more, research is being done in behalf of private industry. One finds many instances of investigations being made for Montecatini, Olivetti, Pirelli

The locksmith: a skilled Italian artisan at work in his shop in Naples' *Galleria*.

and other large organizations, where great pride is taken in the facilities made available for research. In this industrial research, there is more of the American spirit, including a free give-and-take of ideas.

There is one other aspect of teaching which is unfortunate. If a new director is appointed to a department of a university, he may discharge all members of his predecessor's staff and replace them with his own. For this reason, there exist a great deal of insecurity and a rather bad esprit de corps, which may explain much about the jealousy, friction and lack of comradeship.

The pay of the average Italian professor is exceptionally low. The equivalent of $200 per month is considered good. However, he may supplement it by outside consultations, and some specialists – though relatively few – make as much as $800 per month in this manner. The medical professor may make over $1,000 per month. On the other hand, the instructor who carries the burden of university work is paid as little as $50 per month. Postgraduate education is therefore rather frustrating if an individual must make his own way.

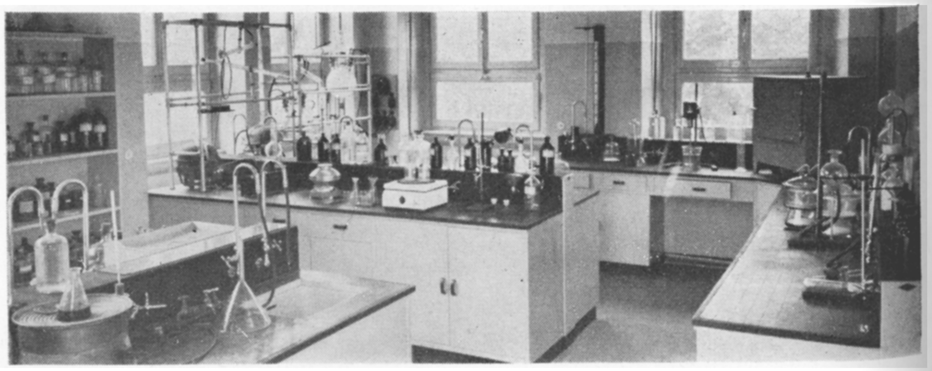
One may well wonder how it has been possible for the Italian university to produce such outstanding contributors to modern science as Enrico Fermi in atomic physics or G. E. Ricci in mathematics. There are many others. The successes achieved by many individuals is a tribute in part to the imaginative character of the Italian mind and in part to sound training in fundamentals.

Sommario: In Summary

The Italian university – in spite of its shortcomings in equipment and teaching methods – is nonetheless an excellent catalyst. So much is available to the student in the way of courses and visiting professors that stimulation of interest is unavoidable if effort is expended to utilize the opportunities afforded. As has been mentioned, the Italian student is more mature than the American and feels more keenly the responsibilities that go with higher education. Whatever the motives for learning, it is axiomatic that interest and effort be bound together, for success is dependent on both. The average Italian student has both of these attributes, and they more than compensate for the many shortages inherent in the higher educational system as well as the lack of adequate laboratory facilities.

I found the Italian university unique and difficult to compare to any university in the United States or any other country. In many ways, it is an anachronism. That higher education in Italy has been successful at all is probably due both to individual efforts of able students and to the imaginative temperament of the Italian mind. As I have tried to show, the Italian university is undergoing a gradual transition – it is becoming more and more like its American counterpart.

Here is one corner of the University of Milan's Laboratory of Industrial Toxicology.



letters

EDITORS: The authors of "Naval Stores Industries – Research Needs," October 1954, deserve a lot of credit for most of the observations and suggestions made. The gum naval stores industry today certainly is "in an excellent raw material supply position;" and their ideas about assigning research problems for graduate work at southeastern universities would be a substantial contribution to the overall research work now being carried on by government and industry. . . .

I should like to take the liberty, however, of calling attention to one or two observations which appear to me to be somewhat overstated. For example, it is our studied opinion that the naval stores field is not faced "with the critical problem of an oversupply of high-priced products and rapidly decreasing outlets for them." I believe . . . just the reverse is true. For a number of years the so-called normal stocks of rosin on hand at the end of a season (March 31) aggregated about a 5 months' supply whereas the overall carry-over estimated at the end of March 1955 probably will be less than that. . . . You will recall that at the recent naval stores work conference in Jacksonville it was predicted that the amount of rosin needed by the paper industry would rise to 600,000 drums by 1975 . . . and the use of rosin soaps in rubber should double by 1975. . . .

I am also inclined to take issue with the statement made in the article that "the gum naval stores industry is rapidly losing its markets to competitive cheaper products from other industries. . . ." It is my belief that the results of past and current research are creating a progressively growing and greater market for gum naval stores. It is true, of course, that the use of turpentine as a solvent is declining, but, as recently brought out at the Jacksonville meeting, its use as an industrial chemical is rapidly expanding. . . .

Milton S. Briggs
Chief, Naval Stores Branch
U. S. Department of Agriculture
Washington, D. C.

EDITORS: In the October 1954 issue we noted an interesting article, "Naval Stores Industries – Research Needs." The suggestions and observations made are excellent in many respects. We do differ, however, with the authors on their statement that the naval stores field is facing a critical problem of an oversupply of high-priced products with rapidly decreasing outlets. Recent changes, brought about primarily from research efforts, tend to reverse the above observation.

We believe, however, that present and future research is the answer to our oversupply ratio.

A. R. Shirley
Secretary & Loan Manager
American Turpentine Farmers Assn.
Valdosta, Ga.

The editors deeply appreciate those thoughtful criticisms by two of the best-informed naval stores authorities. Much of the information they cite was brought out at the naval stores work conference, November 4-5, 1954, shortly after our article was published, and hence was not available to our authors. We are glad that both writers agree with our conclusion on the value of research.

Nuclear Committee Appointed

President Van Leer recently appointed an Advisory Committee on Nuclear Science. It is the purpose of this committee to examine the steps which Georgia Tech should take to render the maximum service in the expansion of research, development work and teaching in the field of nuclear science, which is considered to include the following:

- Nuclear physics
- Nuclear reactors (theory, design and related engineering problems)
- Effects of nuclear radiation (chemical, physical and biophysical)
- Use of radioactive materials
- Measurement of nuclear radiation (applications in industry, geology, civil defense, etc.)


Dr. Boyd

Dr. James E. Boyd, Assistant Director and Head of the Physics Division of the Station, was appointed chairman of the Advisory Committee on Nuclear Science. Dr. Ray L. Sweigert, Dean of the Graduate Division, is vice-chairman, and Vice-President Cherry L. Emerson an ex-officio member.

Other members are Drs. C. H. Braden, M. R. Carstens, B. J. Dasher, J. K. Gladden, M. J. Goglia, W. N. Grune, W. B. Harrison, F. K. Hurd, H. C. Lewis, M. L. Meeks, Earl W. McDaniel, Henderson Ward, W. C. Whitley and L. D. Wyly.

Surveys of the faculty and departments have been begun to determine:

- Previous experience in nuclear science
- Existing facilities for work in nuclear science and closely related fields
- Desirable new facilities
- Consultative or other experience for the Oak Ridge National Laboratory or other AEC installations
- Courses under consideration in this field

Georgia Tech has for several years been a member institution of the Oak Ridge Institute of Nuclear Studies. That fact, plus the recent designation of the Georgia Tech Library as an official AEC industrial information depository, makes the studies of the new Advistory Committee on Nuclear Science most significant, officials said.

While the committee was being established, one member of the Georgia Tech Engineering Experiment Station staff left on a temporary assignment of practical application to the field of nuclear science. Research Physicist John H. Tolan was appointed by the Federal Civil Defense Administration as project officer for the Civil Effects Test Group project concerned with instrument evaluation during the Spring nuclear weapons tests.

Mr. Tolan left Atlanta the first of April to undertake the assignment, in which he will direct a research team with three objectives: to test commercial radiological instruments for civil defense use, to take certain measurements using special instruments and to participate in training radiological defense personnel. It was his second experience in nuclear weapons tests. Two years ago, he participated in the radiological training program.

illustrations this issue

Page	Source
Cover	L. C. Prowse*
4, 5, 6, 7	Thomas H. Buckley, Jr.*
8	A. Thomas Bradbury, Architect
12, 14, 15	Albert Love Enterprises
13, 16	Prof. E. Vigliani, Director, School of Medicine, University of Milan

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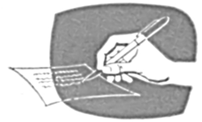

Moder, J. J., Jr., and N. M. Penny, "Industrial Engineering and Economic Studies of Peanut Marketing." 185 pages. Illus. December 1954. Special Report 29. Gratis. (Also published as Bulletin 286, Georgia Experiment Station, Experiment, Ga., University of Georgia College of Agriculture.)

Since 1947 the Georgia Tech Engineering Experiment Station and the Georgia Experiment Station of the University of Georgia College of Agriculture have been conducting cooperative peanut investigations. The joint research team has developed considerable new harvesting and processing machinery. The phase of the work reported in this publication was designed to provide information for increasing efficiency in the peanut-shelling industry by solving specific economic and technological problems. The combination of scientific and engineering specialties utilized is frequently classified by the new term "operations research."

Detailed studies were made of several selected peanut-shelling operations such as sampling and grading, unloading, storage, quality picking and bagging. These studies utilized such industrial engineering methods as time and motion study, materials handling, engineering economy studies and applied mathematical statistics. Time studies, together with engineering-economy studies, were utilized in determining the most economical methods of performing such operations as unloading farmers' stock peanuts and the bagging of shelled peanuts. The operations-research team also evaluated the economics of the electric-eye, quality-picking machine.

A materials-handling study of the shelled peanuts loading operation revealed the possibilities of economies in this operation. Time and motion studies also were used in developing more efficient methods of quality-picking shelled peanuts. Applied statistical techniques were used in analyzing the present system of grading farmers' stock peanuts and devising more adequate procedures.

In 1952 Georgia farmers sold 417 million pounds of peanuts, with a farm-market value of more than $44 million. Peanuts were the fifth largest money crop to the farmers of the state; only cotton, broilers, tobacco and hogs had higher total sales value. It is not surprising, therefore, that the state stands to benefit from increased efficiency in peanut plants.

Hodgden, H. W. and R. S. Ingols, "Direct Colorimetric Method for the Determination of Chlorine Dioxide in Water." Reprinted from *Analytical Chemistry*, Vol. 26, pp. 1224-1226, July 1954. Reprint 87. Twenty-five cents.

Chlorine dioxide was suggested as a sterilizing agent for water as early as 1900, but it was not used on a plant scale until 1944. It is now used to some extent in water treatment for controlling tastes and for the removal of manganese and in the textile, wood pulp and paper industries for bleaching. Tyrosine is selective for chlorine dioxide, producing a color with which there is no interference from hypochlorous acid, chloramines and manganese. The method discussed in this paper for the determination of chlorine dioxide is simple and rapid.

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Dr. Ingols

DR. ROBERT S. INGOLS, Research Professor, has been elected Vice-President and Chairman of the Chemistry Section of the American Association for the Advancement of Science. He will preside over section meetings, and deliver a Vice-Presidential Address, at the AAAS's 122nd national convention, in Atlanta December 26-31, 1955. Dr. Ingols is an authority on bacterial physiology and biochemistry as applied to water and sewage treatment and stream pollution. . . . Another Georgia Tech scientist, DR. M. J. GOGLIA, Professor of Mechanical Engineering and Research Associate, has been named Program Chairman of the AAAS's Engineering Section. . . . The AAAS, the world's largest and most influential group of related scientific organizations, has not met in Atlanta in 42 years. The 1955 convention will be attended by more than 3,000 scientists. Many sessions will be held here at Tech.

Dr. Goglia

DR. RAY L. SWEIGERT, *Dean of the Graduate Division, and* DR. M. J. GOGLIA *(see above) are the co-authors of a new textbook,* Thermodynamics, *published by the Ronald Press Co., New York. Dean Sweigert serves as chairman of a number of committees on engineering education. The book presents basic principles in a form which the authors have used successfully at Georgia Tech for several years. Both are recognized authorities in the field of thermodynamics.*

Dr. Sweigert

REAR ADMIRAL RICHARD C. WILLIAMS, USN (Ret.), has been appointed to an administrative position with the Station. He was graduated from the United States Naval Academy with a degree in marine engineering in 1932. He received four decorations for service in World War II and the Distinguished Service Medal for outstanding performance, more recently, in commanding a Minesweeping Task Group in Korea, before retirement.

Adm. Williams