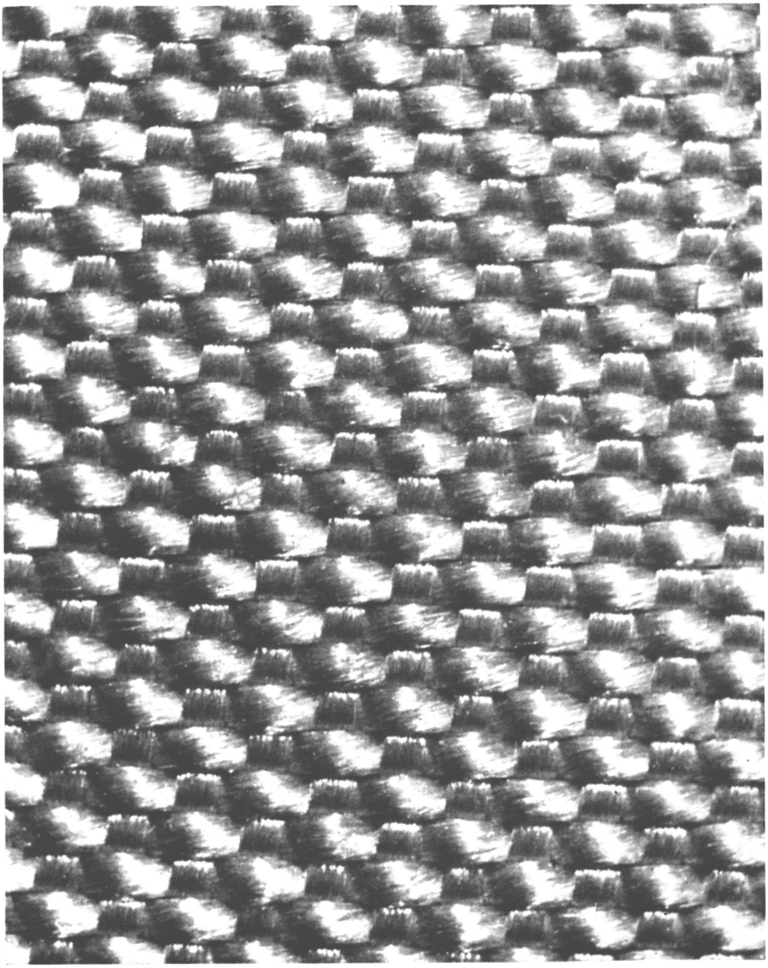
STATE ENGINEERING EXPERIMENT STATION

The Research Engineer

GEORGIA INSTITUTE OF TECHNOLOGY

SEPTEMBER ATLANTA, GEORGIA 1952



The Research Engineer

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OF STARS, PIGS AND RESEARCH

Until the last few decades, Man has been confined to the surface of the Earth—at the bottom of a vast atmospheric sea even from his own viewpoint and on a pebble in space relative to the Universe. Even now, he must still derive his knowledge of astronomical bodies almost entirely from the radiations they emit—and only then from those radiations capable of penetrating the atmosphere. Yet Man's ingenuity is such that he has been able to detect, in the darkness of outer space, bodies that do not seem to give off any visible light at all—so-called radio stars emit-

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Georgia Tech was privileged early this month to act as host for the Sixth Annual Conference on the Administration of Research. Nearly 200 of the nation's top research directors gathered here, for the first time in the South, to discuss the major problems they face today.

Through the splendid cooperation of radio station WGST and television stations WAGA and WSB, four of these men were given the opportunity to broadcast their opinions of the most serious bottleneck to defense and industrial research activities today. Each told the same story—a critical shortage of technically trained manpower is the factor limiting how much research can be undertaken. Funds for additional research are available; men capable of doing this research are not.

I shall not attempt to recapitulate all the four men said. However, I should like to supplement their presentations of the broad problem with some statistics from Georgia Tech's latest annual report.

This June Georgia Tech conferred a total of 1,031 earned degrees in engineering and the sciences compared with 1,337 in June, 1951. That is to say, with demand increasing, the supply dwindled by almost one-fourth. This was true both in the bachelor's degree category which dropped some 22 per cent, from 1,226 to 952, and in the graduate degree group that decreased almost one-half, from 151 to 79.

These figures do not indicate that Georgia Tech suddenly lost its appeal to young men who want to be scientists or engineers. What they do mean is that the birth rate from 1932 to 1937 was low, that the veterans of World War II have about completed their education, and that young men are entering the armed services, thus deferring their education until the U. S. Government will pay for a large share of it.

Industry can help this situation by expanding its assistance and by providing more scholarships and fellowships to worthy applicants. We in the educational institutions will try to do our part by providing faculty and facilities. This will be difficult indeed if we have to compete with industry for scientists. All of you who have sons about to finish high school and you who know such young men can help too. You can add your voices to ours in spreading the word that research is a profession—one offering professional recognition and the opportunity for a lifetime full of useful accomplishments.

BLAKE R. VAN LEER
President, Georgia Institute of Technology

PERMEABILITY OF PARACHUTE FABRICS

By H. W. S. LaVier*

Because of their desirable physical properties and ready availability, parachute designers would like to use fabrics made from synthetic fibers. However, they must be able to specify the rate at which air will flow through the fabric under the conditions encountered in the parachute's use. This article describes the research being conducted at Georgia Tech to provide the information textile mills will need to meet the parachute designers' permeability specifications.

The rescue of flyers from today's high-speed, high-altitude airplanes and the safe delivery of heavy pieces of air cargo by parachute require the development of parachute fabrics having both good strength and satisfactory, predictable permeability to air. Permeability, as the term is used here, may be measured as the volume of air that flows through a specified area of cloth in a unit of time at a given pressure differential. As might be expected, the permeability of the fabric is an important factor in the rate of descent of a parachute of given size and given load.

Synthetic fibers, such as nylon, Orlon and Dacron, offer some important advantages for parachute fabrics—long life, freedom from rot and mildew effects and, not the least, ready availability. A study of the air permeability of parachute-type fabrics made from these synthetic fibers is now being conducted by the State Engineering Experiment Station for the Textile Branch of the Wright Air Development Center's Materials Laboratory. The over-all research program, which is administered by the Chemical Sciences Division, involves the coordinated activities of faculty members from Georgia Tech's Schools of Aeronautics, Textiles and Mechanical Engineering. This article is intended to describe the ways in which the problem is being attacked.

Development of Equipment

Since it was desired to test the potential parachute fabrics at pressure differentials many times greater than the 0.5-pound per square inch limit of air permeometers currently in use in the textile field, it was early apparent that special equipment would have to be designed and constructed. The first specially designed permeometer was made to

*Research Engineer and Research Associate Professor, Daniel Guggenheim School of Aeronautics.

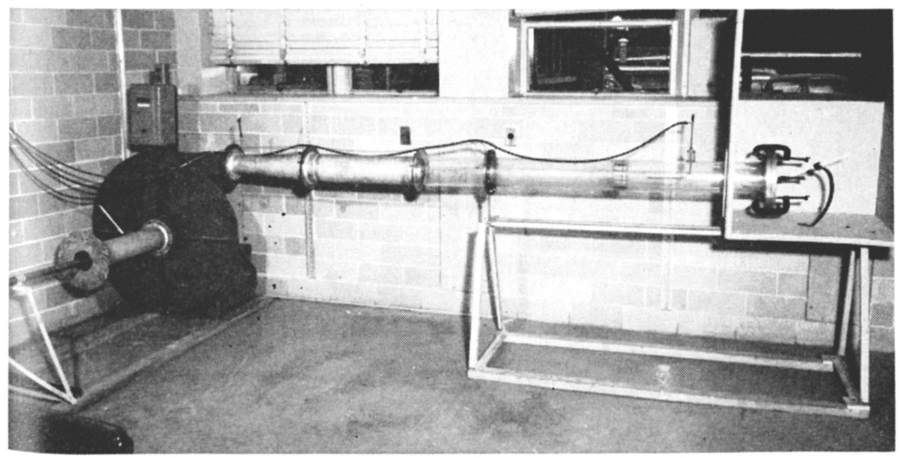
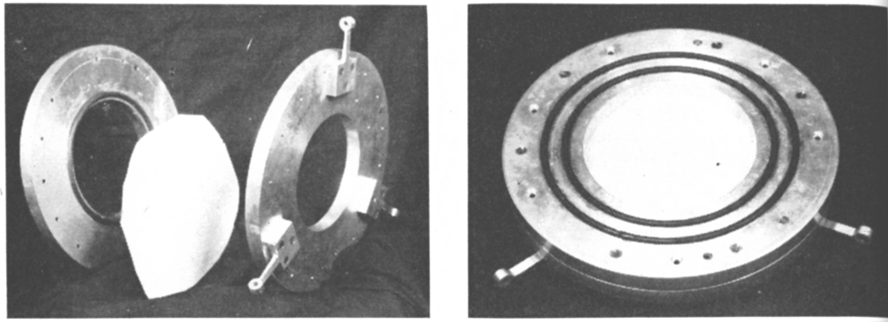


Figure 1. This permeometer was specially designed to measure air flow through fabric samples at varying pressure differentials up to 2.5 pounds per square inch.



Figures 2 and 2a. This aluminum sample holder is used to attach fabric samples six inches in diameter to the end of the duct shown in Figure 1.

measure the air flow through cloths at varying pressure differentials up to 2.5 pounds per square inch. It employs what is essentially a small wind tunnel, as shown in Figure 1, to which air is supplied by a centrifugal Buffalo Forge blower driven by a 7.5 horsepower electric motor. This air is carried through a cylindrical Plexiglas duct 5.75 inches in diameter, which is equipped with "egg-crate" flow straighteners. An orifice meter inserted between the straighteners permits measurement of the quantity of air flowing through the system. The sample fabric is installed in an aluminum sample holder, as shown in Figures 2 and 2a, which is then clamped to the end of the duct. The pressure differential across the cloth is measured by a water manometer and that across the orifice by an alcohol manometer. This permeometer tests fabric samples 6 inches in diameter.

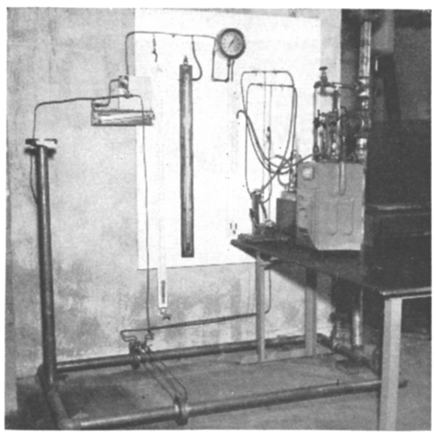


Figure 3. The permeometer shown here was designed to test the permeability of fabrics at pressure differentials as high as 10 pounds per square inch.

Pressure differentials as high as 10 pounds per square inch have been obtained with the permeometer shown in Figure 3, which is supplied with compressed air by facilities of the School of Mechanical Engineering. The size of the fabric sample tested with this permeometer is 2.06 inches in diameter.

A modified supersonic wind tunnel will be used for tests at pressure differentials up to 54 pounds per square inch. Air supplied by a 12" x 13" Worthington compressor will be dehumidified by a drier employing silica gel as the adsorbent. The compressed air will be cooled and stored in a 1,000-cubic foot reservoir. A pressure regulating valve will maintain a constant pressure as the air in the reservoir is discharged into the wind tunnel. Present plans call for testing the fabric permeability at temperatures as low as —20° F. and as high as 130° F. at various humidities. As well as directing the air through the fabric sample, a special wind tunnel will house the temperature and pressure pickups necessary to determine the quantity of air flow through the fabric. Four-inch-square fabric samples will be tested with this equipment. The transient conditions resulting from impact loading of

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SOME RECENT DEVELOPMENTS IN READING

By Tom F. Almon*

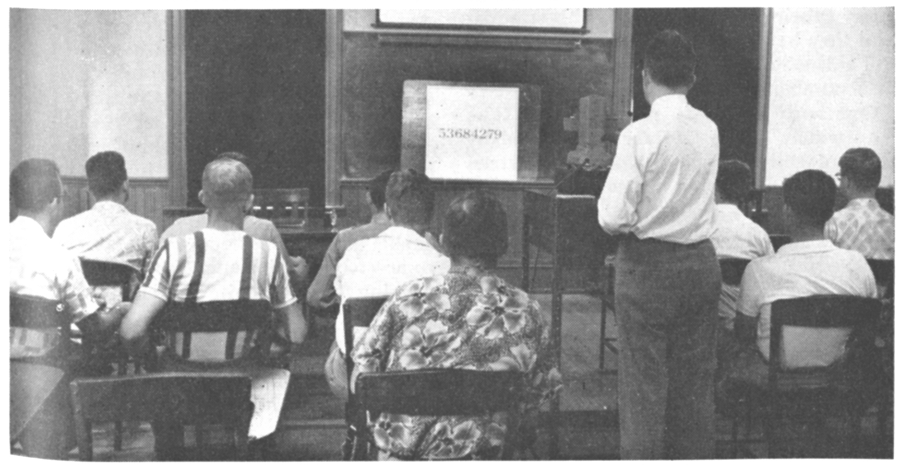
Men highly placed in business and industry, as well as those in the scientific and other learned professions, must read extensively to keep abreast of developments in their fields. This article discusses recently developed techniques that can help them increase their rates of reading and their comprehension of what they read.

In recent years many adults in business and the professions have felt an urgent need to increase their reading rates in order to deal competently with the greater and greater amount of material which they have to read. Business executives and professional leaders have been enrolling in college reading classes, and many have taken individual training to speed up their reading. Only recently *Business Week* carried an article on the popularity of individual reading training with a group of business executives from such well-known firms as the United States Steel Export Company, Motorola, Inc., Acme Steel, Ryerson Steel Corporation and others.[1] More and more people are becoming interested in recently developed techniques in reading which can train them to at least double their rate of reading and help them to comprehend better what they read.

Assistant Professor of English.

Much of this interest has arisen as a result of research and experimentation in the field of reading in recent years.

This experimentation has resulted in various theories about the best way to increase a person's reading rate. Prominent among these theories is the conviction that deliberate training in certain physical aspects of the reading process can be of definite help to most people. Supporters of this theory think that many adults have through the years developed inefficient reading habits of a physical nature, such as lip-reading, inward verbalizing or internal hearing of the words, word-by-word reading, and going back or "regressing" unnecessarily. Furthermore, they feel that in most cases an adult can, through training, rid himself of those habits and substitute desirable ones.



One device to increase the reading rate is the tachistoscope which projects digits or other symbols on a screen at high speed.

From the physical standpoint, an adult who wishes to increase his rate of reading must acquire certain abilities. He must make efficient use of his perceptual span; that is, he must see as many words as possible in one fixation of the eye. Also he must not dawdle but spend as little time as possible on the stops which occur between the sweeps or jerks of the eye. He must not needlessly regress, and he must not pronounce either vocally or sub-vocally the words which he reads.

Some reading experts feel that the best way to acquire these abilities is to learn to comprehend fully and effectively the material that is read. They say that if an adult has an adequate vocabulary, can determine main ideas and relationships between ideas in a written passage, can interpret and evaluate what he reads, he will automatically acquire desirable reading habits of a physical nature and will thus increase his rate. In other words, if a reader comprehends easily and well, he will as a matter of course read fast.

But other authorities in reading feel that, on the adult level at least, training and deliberate practice are needed to acquire desirable reading habits of a physical kind. They hold the view that some compulsive stimulation is necessary to eliminate the old, inefficient habits of reading that are firmly established and to form satisfactory ones in their place. To provide this stimulation they have made use of several mechanical aids which have proved quite successful in a number of reading classes.

One such device is reading films. The most widely used set of these, compiled by Harvard University, is composed of sixteen films, each containing a reading selection that projects at a faster speed than the one before. Only a single group of words appears on the screen at a time; as each group flashes off, the next one in the line appears. The early films in the series show small groups of words, but as the series progresses, the groups become larger. When the reader has read each film, he takes a comprehension test on the material he has read.

The films are designed to force the student to habituate himself to seeing quite rapidly a group of words rather than a single word and to break down the habit of regressing.

This device employs a shutter that descends over the page at a predetermined rate.

Another device is a reading accelerator. This device is equipped with a shutter which descends over a page at a predetermined rate. To read the page the reader is forced to keep ahead of the shutter. He must read a little faster than he has been accustomed to doing. To do this he must widen his perceptual span and break the lines into groups of words. He cannot regress, for the shutter covers each line as soon as he has read it.

A third device that has been used to increase reading rate is the tachistoscope. This device is simply a projector equipped with a shutter to form a flash-meter; using slides, it projects digits or other symbols on a screen at high speed, the speed being determined by the setting of the shutter. The tachistoscope was used during the war by certain military groups in training for quick recognition of ships and aircraft. The objective of tachistoscopic training is to enable a person to see an image quickly and completely. For instance, many people after training can recognize an eight- or nine-digit number in 0.01 second without being conscious of the individual digits composing the unit. A fast reader does the same kind of thing in reading. He sees groups of words, or thought units, quickly and completely, without moving tediously from left to right

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ELECTRON DIFFRACTION

By JOHN L. BROWN*

Electron microscopy and x-ray diffraction have been described in previous issues. This article discusses yet another modern method of obtaining detailed information on the structure of materials.

From the latter part of the seventeenth century to the middle years of the nineteenth, physicists passionately argued a question which in the light of modern concepts seems to call for a compromise answer. The question concerned the apparent duality of the nature of light, the behavior of which could be explained to some extent by either a particle or a wave theory. Louis de Broglie was the first to reconcile the wave and particle properties of light by proposing that there was a certain definite wave length associated with every moving particle and that this wave length λ is equal to $\frac{h}{mv}$, where h is Planck's constant, m is the mass and v the velocity of the particle. The first confirmation of the de Broglie theory was found in the work of Davisson and Germer[1] in America and, almost simultaneously, in the work of G. P. Thompson in England. Davisson and Germer's apparatus, which was mounted in an evacuated glass tube, consisted of an electron gun which fired a stream of electrons at normal incidence to the face of a nickel crystal and a Faraday-

*Research Assistant.

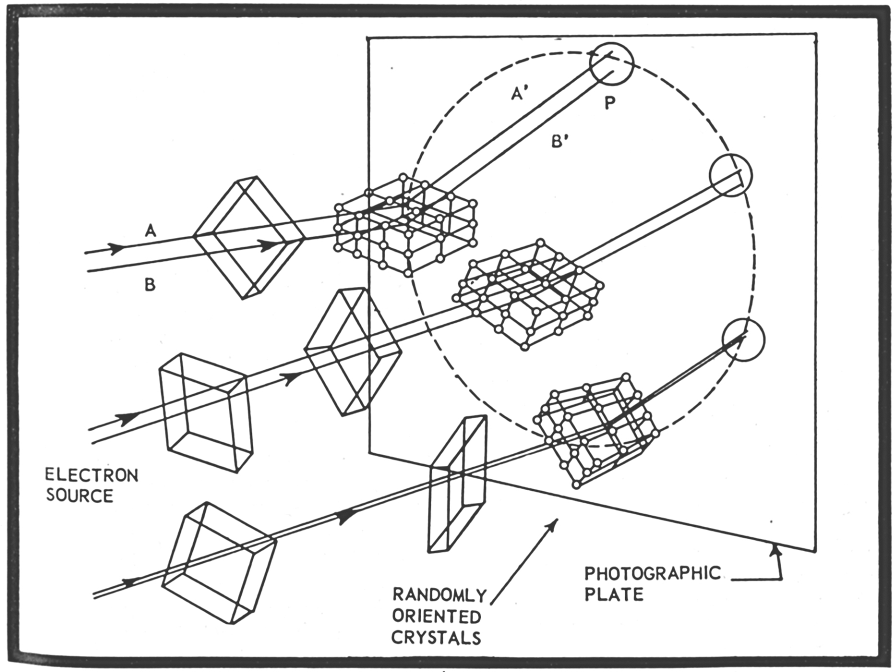

Figure 1. By reflection off adjacent planes in their lattices, randomly oriented crystals refract electron beams to produce rings of spots.

type electron collector to determine the intensity of the scattered electrons at different angles to the crystal face. They found maxima and minima of intensity which depended upon the voltage accelerating the electrons and the angle of the collector to the face. This suggested that the electrons were behaving like waves and were being diffracted by the atomic-grating structure of the nickel just as light waves are diffracted by a ruled optical grating. Such a possibility had not occurred to de Broglie; and, since Davisson and Germer were attempting to investigate reflection of electrons from metal surfaces, the discovery of electron diffraction was accidental, as numerous important discoveries of science have been.

At about the same time, G. P. Thompson and A. Reid[4] in Britain were doing work that more nearly approximated present-day techniques of electron diffraction. Their apparatus passed fast, or high-voltage electrons through a thin film of the material under study, and the diffracted electrons formed a pattern upon a photographic plate placed beyond the specimen. When these patterns were measured and compared with those obtained from x-ray diffraction, the pioneer method for analyzing crystalline lattices, the results checked within the limits of experimental error. Thus, Davisson and Germer may be credited with discovery of the phenomenon of electron diffraction and Thompson and Reid with first employing fast electrons to obtain transmission diffraction patterns of the type now useful in studies of the nature of materials.

Crystal Structure

Long before anything was known of either electron diffraction or x-ray diffraction, it was theorized that crystals were a regular structure built up of some basic unit. From the geometry of a crystal, its molecular weight, density and number of molecules per gram molecule, the distance between neighboring atoms in such a structure was calculated to be about 1 Å, or about four-billionths of an inch. To aid in describing a crystal, Hauy[3] suggested that the intersections of the three nonparallel faces of a crystal be considered to define a set of axes suitable for use as a coordinate system. When a plane was made to intercept these three axes at some point other than the origin and when the axial distance of each intersection from the origin was denoted by *a, b* and *c,* Hauy found that all faces of actual crystals are always parallel to planes having intercepts a/h, b/k and c/l, where h, k and l are small integers. Known as the law of rational indices, this is one of the fundamental laws of crystallography. Later other workers pointed out that this law and other facts about crystallography can be explained by assuming that crystals are built up of elementary particles arranged at the corners of a space lattice. This space lattice can be thought of as consisting of any single chosen set of rational planes. The crystal system can be identified by the type of coordinate axes used to specify the symmetrical arrangement of atoms in the space lattice.

There are six general systems of crystals based upon the ratio and angle of their different dimensions. The simplest system, that in which the three axes are all orthogonal, is known as the cubic system. Its unit cell, or smallest divisible part of the crystal, is in the shape of a cube with an atom at each corner. Since only a general idea of crystallography is necessary for an understanding of electron diffraction, the other systems will not be discussed here.

It is easily seen that in a crystal composed of many unit cells there are many possible sets of atomic planes having different spacings or "d" values as they are usually called, and some method is necessary to designate these different planes. Let us consider a cube-shaped crystal consisting of a number of these unit cells. If we take one corner of the crystal as the origin of a coordinate system and the adjacent edges as the axes, we can designate any given plane by its intercepts in units of atomic spacing along the axes. This will single out one particular plane. However, if we find the lowest three integers proportional to the reciprocals of the three intercepts we will have a set of numbers describing all planes parallel to this particular plane. These numbers are known as the Miller indices of the plane and are usually written in parentheses. For example, (001), (010) and (100) are the

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EXPANDING ACTIVITIES IN THE SCHOOL OF ARCHITECTURE

By T. B. A. Godfrey, H. K. Menhinick and Hin Bredendieck*

In addition to inauguration of new curricula in city planning and industrial design, the School of Architecture's expanding activities include initiation of a program of research in all departments. Consolidation of the School's facilities in its fine new building, to be dedicated on September 20, and the provision of additional State funds are two major factors making such expansion possible. This article describes the School's new activities and gives some idea of the benefits that will result.

The School of Architecture is currently undergoing a peaceful revolution of major proportions. In the past, the School has been able to give its students training in only part of its proper field of activity, which is the whole problem of physical environment. However, a recent grant of the General Education Board, matched by the Georgia State Board of Regents, and the completion of the new Architecture Building have enabled a very considerable expansion in the range of teaching.

At one end of the scale, the planning of cities and regions, the new curriculum headed by Professor Howard K. Menhinick deals with the physical, cultural, and political environment of men in communities. At the other end, in the design of objects for human use, the new curriculum headed by Associate Professor Hin Bredendieck deals with the relationship between the individual, the artifact and the industrial process. Inauguration of a program of research in all departments will be made possible by the grant. These developments supplement the existing training in environment as expressed architecturally through buildings and building complexes. Together, the various curricula will permit a more

**Respectively, Assistant Professor, School of Architecture, Regents' Professor of City Planning and Associate Professor in Charge of Industrial Design.*

Consolidation of the School of Architecture's facilities in this new building has helped make possible its expanded activities.

complete study of the physical elements affecting human living, their psychological implications and, most important, the opportunities which can be found in them for the creative development of our surroundings.

Expansion of curricula has been matched by that of facilities. The new Architecture Building provides laboratory and exhibition space for design work, better housing for the library and classrooms, space for the study of materials and a shop. For the first time the school will be able adequately to correlate in one building the work of its different departments, to use exhibition techniques effectively as a teaching instrument and to engage in research.

In clarifying the role of architecture and the School in modern society and within the Institute, a statement of aims and convictions prepared by members of the faculty is pertinent here:

"The teaching of the School of Architecture is founded on these convictions:

that architecture must be the physical expression of the most advanced capabilities of contemporary culture;

that the architect, planner and designer must assume the leadership in organizing our environment with human understanding, recognizing that technology, science and art are all elements of the designing process; and

that to master the professional process of organization of resources, use of techniques and objective interpretation of personal desires, the student graduating in architecture must attain the qualifications listed below.

1. A basic knowledge and appreciation of the physical and applied sciences
2. A critical and analytical comprehension of our cultural past and present
3. An expanded and sensitized response to the physical world
4. An understanding of human needs, motives and aspirations
5. The ability to evaluate and control the elements of sensory impression
6. The ability to apply in the design process research, analysis and synthesis, with logic and a sense of relative values
7. An interest in allied fields and an understanding of the essential unity of all creative activity
8. An appreciation of the administrative, financial and legal aspects of professional practice
9. Facility in all aspects of presentation of design ideas
10. Proficiency in the realization of design ideas in terms of construction techniques
11. A consciously evolving personal philosophy of creative action"

The scope of activity embraced by this program is large, and its accomplishment is difficult in the light of limited time, conflicting activities and the extent of confusion of contemporary thinking in the fields of the arts. This confusion permeates one of the major processes of human activity—that whereby we organize and state in physical terms (e.g., paintings, utensils, buildings, parks, etc.) our thoughts and feelings about our relationships to the objects and spaces around us. It must be resolved if we are to achieve in the twentieth century any balanced and successful culture. The School of Architecture is an instrument in the resolution of this confusion; through its study and teaching of the elements of controlled environment, it develops the art of providing more effectively for physical and psychological living requirements.

In this activity, which deals with the art as well as the mechanics of living, research has an important part. It is needed both for its contribution to total knowledge of the subject and for its stimulation of a logical, inquiring pattern of thought in the students under its influence. Architectural research activities can be roughly divided into technological studies and human studies, the first consisting of investigations into the mechanical problems of design and the second of investigations into the nature of the user of (or dweller in) the designed product and those personal or group characteristics which influence his need for it. To date, the latter field of study has not been the subject of such complete investi-

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RECENT STATION PUBLICATIONS

These abstracts cover publications subsequent to those listed in our March, 1951, issue. Others will be published as space permits.

BULLETIN

T. A. Wastler, P. M. Daugherty, and H. H. Sineath, *Industrial Raw Materials of Plant Origin*, Bulletin No. 13, 1952, 38 pages. Gratis.

This bulletin, the first of a planned series on industrial raw materials of plant origin, discusses economic and technological developments in the field of fixed vegetable fats and oils during the period January 1-July 31, 1952. It was prepared as part of a study of United States needs for such materials, which study is being conducted for the Division of Plant Exploration and Introduction, Bureau of Plant Industry, Soils and Agricultural Engineering, United States Department of Agriculture, under the Research and Marketing Act of 1946. Following a general summary of the more important developments in the field during the period surveyed, the bulletin presents specific information on the demand for, supply and uses of vegetable oils of the following general classifications: drying oils, other oils having established uses, and new oils having considerable potentialities for industrial use. Drying oils covered include dehydrated castor oil, linseed oil, oiticica oil, soybean oil and tung oil. Oils having other established uses include babassu oil, castor oil, coconut oil and copra, cottonseed oil, olive oil, palm oil, peanut oil, pine oil, rapeseed oil and mustardseed oil. The new or relatively new vegetable oils discussed are: black spruce oil, gokhru oil, grapeseed oil, kamala oil, mowrah oil, nim oil, pilchard oil, pisa fat, khakan oil, phulwar oil, queenroot oil, rice bran oil, safflower oil, sesame oil, sorghum grain oil and sunflower-seed oil. In the section on new technological developments, reference is made to the production of fats by certain microorganisms, such as strains found in Penicillia, Aspergilli, Endomyces, etc., and to a solvent-extraction process under pilot-plant study at the Southern Regional Research Laboratory.

REPRINTS

R. S. Ingols, E. H. Shaw, W. H. Eberhardt, and J. C. Hildebrand, *Determination of the Fluoride Ion with Ferric Thiocyanate*, Reprint No. 42, 1950, 5 pages. Twenty-five cents.

The addition of fluorides to drinking water as a preventive against human tooth decay requires a method for quantitatively determining the concentration of fluoride ion present in water samples that may contain many other ions. One method of fluoride ion determination depends upon the change in color that takes place in the ferric thiocyanate complex when in the presence of the fluoride ion. However, other ions, such as iron and sulfate, that may be present in natural waters interfere with the determination of fluoride concentration by this method. In this article, reprinted from the June, 1950, issue of *Analytical Chemistry*, the authors describe a modification of the method that they have found to overcome this interference and to be both sensitive and rapid. In it, the sensitivity of the ferric thiocyanate complex toward a given amount of fluoride is indicated by the difference in color intensity between a water sample to which zirconyl ions have been added (as zirconium oxychloride) and a tube of distilled water containing the ferric thiocyanate reagents. The method has been found to be as sensitive as the standard zirconium alizarin technique of fluoride determination and free of some of its disadvantages.

J. W. McConnell and R. S. Ingols, *Sulfate Ion Determination with Benzidine Dihydrochloride*, Reprint No. 43, 1950, 3 pages. Twenty-five cents.

In the analysis of water, the concentration of sulfate ion can be determined by precipitating the ion as benzidine sulfate, filtering the precipitate, suspending it in water and titrating it with sodium hydroxide to a phenolthalein end point. However, this procedure can be applied only over a range of 120-500 parts per million of sulfate ion; it is accurate to only one part in twenty; and it requires the additional titration of a blank sample. This reprint of an article from the August, 1950, issue of *Water and Sewage Works* describes a modification of the standard technique, which modification is applicable over a range of 2-400 parts per million, is accurate to 1.5 per cent or better over the range of 20-200 ppm, and does not require a blank titration.

M. A. Honnell and M. D. Prince, *Evaluating Video Bandwidth and Picture Quality,* Reprint No. 44, 1950, 3 pages. Twenty-five cents.

To what extent restriction of the video bandwidth of television systems, both transmitters and receivers, can be practiced in the interest of economy without sacrificing the quality of the picture too seriously is the subject of this article reprinted from the September, 1950, issue of *TeleVision Engineering*. The problem was attacked experimentally because of the complex psychological factors involved in the theoretical evaluation of the ability of a system to reproduce a typical dynamic scene containing fine contrast gradations. The over-all bandwidth of a television system was varied in discrete steps and its performance was evaluated under each bandwidth condition. The procedure by which this was done through an unconventional application of standard shunt-compensation techniques is described in some detail. The study indicated that considerable reduction in bandwidth is permissible without significantly altering the general appearance of the image.

J. M. DallaValle, C. Orr, Jr., and R. R. Cornwall, *Limitations of the Arealometer Method for the Measurement of Fiber Diameters,* Reprint No. 45, 1950, 7 pages. Twenty-five cents.

The arealometer (or permeameter), which is widely used in the textile industry to determine fiber fineness, actually measures surface area which, in turn, is related to some average diameter of the fiber tested. For accurate measurement of surface area, the porosity or void fraction of the bed of material under test must be uniform throughout, a condition difficult to obtain with fibers and, at best, calling for tedious alignment. The experiments reported in this reprint from the *Textile Research Journal* for October, 1950, were conducted in an arealometer chamber larger than those ordinarily employed by textile workers in order to minimize the effect of nonuniformity of the fiber bed. The results revealed hitherto suspected, but unconfirmed, limitations of the general procedure.

J. R. Munger, R. W. Nippler, and R. S. Ingols, *Volumetric Determination of Sulfate Ion,* Reprint No. 46, 1950, 3 pages. Twenty-five cents.

From the literature, it was evident that the disodium salt of ethylenediamine tetraacetic acid (Versenate) could be used to determine the concentration of barium ion when employing the dye, Eriochromeschwarz T, as the indicator. The authors have developed a volumetric method for determining sulfate ion concentration by adding standardized barium chloride solution to a sample and determining the barium added in excess of that necessary to precipitate the sulfate. The barium sulfate precipitate need not be removed before titration of the excess barium ion. This procedure will find its major usefulness only in laboratories also employing the Versenate method for determining total hardness of water, since the value of the combined calcium and magnesium ion concentrations is required for calculating the sulfate ion concentration. This article is reprinted from the November, 1950, issue of *Analytical Chemistry.*

W. H. Burrows, *Construction of Circular Nomographs with Hyperbolic Coordinates,* Reprint No. 47, 1951, 2 pages. Twenty-five cents.

In Reprint No. 15 (1946), the author pointed out that the use of hyperbolic coordinates greatly simplifies nomograph construction because of the ease with which the positions and moduli of the nomographic scales can be altered to accommodate the ranges of the variables represented. In the present article, reprinted from *Industrial and Engineering Chemistry* for January, 1951, the application of hyperbolic coordinates to circular nomographs is discussed. Here the simplicity they afford is enhanced by the fact that circular nomographs are also based on a hyperbolic abscissa scale. This scale, with a range from zero to infinity, provides a nomographic form which, in certain cases, is superior to the usual logarithmic-type and Z-type nomographs for multiplication.

W. H. Burrows, *Construction of Nomographs with Hyperbolic Coordinates—General Hyperbolic Coordinates,* Reprint No. 48, 1951, 4 pages. 25 cents.

The author has previously described the construction of nomographs consisting of an X axis subdivided hyperbolically and a Y axis subdivided linearly. In this article, reprinted from the May, 1951, issue of *Industrial and Engineering Chemistry,* he takes up those in which both axes are subdivided hyperbolically. There are several fields of nomography in which this geometrical device simplifies constructions. One involves the V-type of nomograph. Another use is in simplification of the problem of fitting nomographs of irregular form into a rectangular form.

M. A. Honnell and M. D. Prince, *Television Image Reproduction by Use of Velocity-Modulation Principles,* Reprint No. 49, 1951, 4 pages. 25 cents.

In the basic type of velocity-modulation television, changes in the brightness of the image are produced by varying the horizontal velocity of the scanning spots both in the camera tube and in the kinescope. Bright portions of the picture are reproduced by low velocities and dark portions by high velocities. This article, originally published in the March, 1951, issue of the *Proceedings of the I.R.E.,* describes a system using a combination of standard video principles for image pickup and velocity-modulation methods for picture reproduction. The quality of images obtained by velocity-modulation of standard television broadcasts is too poor for entertainment purposes. However, one form of velocity reproduction imparts a three-dimensional appearance to two-tone subject matter and may find some application in the reproduction of printed material and line drawings or in radar scope displays. The observation of standard television broadcasts on a modified receiver indicated that an apparent improvement in resolution may be obtained by using the proper degree of velocity modulation in combination with modulation of beam intensity. The investigation also indicated a type of picture distortion that may arise in standard television systems as a result of spurious signals coupled into the horizontal or vertical sweep circuits.

J. M. DallaValle, C. Orr, Jr., and H. G. Blocker, *Fitting Bimodal Particle Size Distribution Curves,* Reprint No. 50, 1951, 4 pages. Twenty-five cents.

Multimodal probability distributions are fairly often encountered in the study of physical phenomena. With increasing interest in particle-size distributions over wider and wider ranges of size, greater consideration must be given to mathematical methods for describing bimodal and other multimodal size distributions. This paper discusses methods for analyzing bimodal distributions in particular, but the method favored can be expanded to multimodal forms. The derivation of a selected-ordinate method is described; and, through application to two bimodal distributions obtained from aerosol aggregation studies, this method is shown superior to the more complicated methods of moments and least squares. The paper originally appeared in the June, 1951, issue of *Industrial and Engineering Chemistry.*

W. H. Burrows, *Construction of Three-Dimensional Nomographs,* Reprint No. 51, 1951, 4 pages. Twenty-five cents.

Although three-dimensional nomographs offer a convenient means of handling formulas with a proportionately larger number of variables than handled by two-dimensional nomographs, they are somewhat more difficult to construct and to read. Their potential value for expressing engineering formulas has not been tested in practice because such nomographs have been virtually nonexistent. This article, reprinted from the August, 1951, issue of *Industrial and Engineering Chemistry,* presents comparatively simple methods for the construction of three-dimensional nomographs. In addition to their application as aids to computation, nomographs are useful for the graphical representation of functionally related parameters, serving as aids to visualization of involved relationships. Here, the method of reading need not be precise, and three-dimensional nomographs are particularly well adapted to this purpose. They offer a means for demonstrating relationships among four related parameters that is not easily achieved with three-dimensional graphs.

R. A. Martin and R. D. Teasdale, *Input Admittance Characteristics of a Tuned Coupled Circuit,* Reprint No. 52, 1952, 5 pages. Twenty-five cents.

In certain oscillator problems of current interest, it is desirable to design a coupled circuit whose total phase deviation will be less than a specified amount over the widest practical frequency range. This paper, reprinted from the *Proceedings of the I. R. E.,* January, 1952, presents a steady-state analysis of a tuned coupled circuit to determine the input admittance when the primary Q is high and the secondary Q is low. Values of the coupling coefficient and Q_2 may be chosen to obtain either a specified phase deviation or a specified bandwidth. Use of the specific numerical curves should result in a considerable saving in the designer's time. General relations are given, which permit computation of similar curves for any application requiring the circuit described.

R. N. Miller and W. E. Robertson, *Double Shelf Life?—It's "In the Bag,"* Reprint No. 53, 1951, 3 pages. Twenty-five cents.

This article, reprinted from *Food Engineering*, July, 1951, describes research that led to greatly increased shelf life for packaged potato chips. Freshness and crispness are preserved through inclusion in the bag of a small packet containing activated carbon and silica gel. Excess moisture is removed and odors are absorbed by the packet as they develop within the bag. The methods and results of aging tests are included, as is a list of some 40 substances previously tested as antioxidants.

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Editor's note: Regular readers of **The Research Engineer** may have noticed that we have not, for some time, printed abstracts of theses prepared by Georgia Tech students in partial fulfillment of the requirements for advanced degrees. This is because the Graduate Division plans to do so soon in a special bulletin.

EXPANSION IN ARCHITECTURE SCHOOL

Continued from Page 10

gation as the former, and it seems desirable in an institute like Georgia Tech to supplement the very extensive technological studies of other departments with a more complete investigation of the nature and needs of those individuals benefiting from their studies. While allowing free rein to any worthwhile projects, the program of research in the School of Architecture will, therefore, encourage basic research into the nature of the relationships between the human being and the physical elements of his environment. It will aim at providing a larger fund of knowledge for the practitioner and a fuller knowledge of the nature of his profession for the graduating student.

City Planning

The graduate instruction in city planning will focus principally on the problems involved in planning both small and large communities and metropolitan areas. As a contributing secondary objective, some attention will be given to the problems of state, regional and national planning and the development of resources because of their obvious interrelationships with the problems of cities.

Urban planning was selected for emphasis as the core of the curriculum for several reasons. The staffs of Georgia Institute of Technology and of the other institutions of higher learning in the region who will cooperate in the instruction are particularly well qualified to deal with problems of city planning. Furthermore, practicing city planners and men from other professions who have special training, experience and skills in the various aspects of city planning and development are available in the Atlanta region for supplementary instruction. Another reason for this choice is the fact that Metropolitan Atlanta, at the doorstep of Georgia Tech, and the many rapidly growing small to medium-sized cities of the Southeast constitute unexcelled planning laboratories.

Instruction in city planning is particularly timely. Cities of the Southeast, retarded in growth for many years, are now expanding rapidly. These cities have an unparalleled opportunity to avoid the mistakes made in the past by the cities of the more highly urbanized regions of the United States. Finally, in the Southeast and throughout the country there is a need and a demand for a much larger number of well trained city planners than is presently available. The program envisions enrollment of students of varied backgrounds—architecture, landscape architecture, civil engineering, economics, sociology, geography and the humanities. Men with training in each of these fields can make unique contributions to city planning. In working together as a team in the solution of city planning problems, a group of students with diverse backgrounds gains valuable experience and first-hand knowledge of the techniques and possible contributions of the various professions as well as the habit of collaboration—an experience which will be of continuing usefulness to the students in their subsequent professional careers.

To obtain the degree of Master of City Planning, most students will spend a total of two years—five quarters in course work plus one quarter on a thesis. The intervening summer will be devoted to an internship in an approved planning office on assignments agreed to jointly by the planning office, the student and the school. To the extent feasible, the thesis will be the solution of an actual problem in a city, and the thesis conclusions will be presented by the student to the appropriate agency of the city, normally the city planning commission or the city council, and to the school.

The core of the curriculum is a series of drafting room and field projects given in a series of courses entitled "Problems in City Planning." The problems parallel instruction given in seminar courses. Thus tied together are problems and seminars in land-use planning; land-subdivision design and regulation; the planning of street, transit and utility systems; railways and airports; schools and public open spaces; residential, business and industrial districts; and all the other elements that comprise a comprehensive city plan. Likewise, the problems of designing a new town are taken up in seminars in which the final projects are development of a system of local government, a public finance program and a zoning ordinance. The problems encountered in urban development projects are covered by seminars in housing and urban redevelopment and in sociological and psychological techniques for planning. The final project in the latter seminar is identification and solution of the human problems that are inherent in an urban redevelopment enterprise. A course in statistics makes use of population data being studied in a parallel course entitled "Planning for People." Introductory design and graphic presentation (for those who enter without training in these fields) will be taught, for the most part, through the medium of the situations and problems encountered in city planning.

Several courses represent innovations in traditional city planning instruction. Among these is a two-quarter course in "Developing and Presenting Planning Ideas," in which concentrated attention will be given to speaking and writing on planning subjects. Each student will be required to address a public audience or give a radio talk and also to prepare a manuscript, suitable for publication, on some aspect of city planning. A course entitled "Planning for People" and a second course entitled "Economics of Urban Development" will give the student an insight into the social and economic purposes, organization and functioning of cities. He will study techniques for appraising the effects of city plans upon the lives of people and upon the economic resources of the community. How to evaluate community resources and develop plans that are within the scope of a community's ability to pay will receive particular attention. Another course, entitled "Sociological and Psychological Techniques for City Planning," is based on the premise that citizens should make the important planning decisions and that the function of the planner is to show the alternative possibilities and to aid in the making of wise decisions. Accordingly, the first part of the course is devoted to development of the basic principles of human behavior and of democratic methods for managing conferences and arriving at group decisions. Their application to typical planning situations will be illustrated in the classroom and in attendance at hearings and other public meetings. The course, itself, will be conducted so as to become an experience in group participation and a medium for developing individual leadership ability in the field of planning. This will be accomplished, in part, through role playing in typical human situations involved in urban planning and urban redevelopment.

A course in "Government Aspects of Planning" will deal not only with the traditional structure and functioning of local government but also with the politics of planning. Finally, there is a series of seminars in which students, faculty and invited guests will join in informal discussions of current planning subjects and other matters of special interest to the group. In addition to required courses, most students will have an opportunity to take a number of elective courses.

The city planning curriculum will require intensive work on the part of both students and faculty. It has been developed on the assumption that graduate students will be carefully selected mature men of more than average ability. The curriculum is aimed at providing enough training in the tools of the profession so that, on completion of the work, the graduates will be able to take their places as useful members of staffs of planning agencies or as planning consultants. It is also aimed at giving the students a broad understanding of cities, their functioning, their planning limitations and possibilities so that, in ensuing years, they may rise to positions of planning leadership. Of course, the basic objective of the city planning curriculum is, as it should be, to provide young men with the training that will qualify them to contribute to the improvement of the urban environment in which increasing numbers of the people of our country are destined to live and work.

Industrial Design

The Industrial Design option of the School of Architecture is a recent reactivation of a course given some years ago. It is concerned with the development of those products of industry with which man, through use, has a direct relationship, visual and physical. While it excludes the actual development of technical objects such as motors, pumps, electric bulbs, etc., it does not exclude their applications, which are worked out together with the engineer.

The industrial designer concerns himself with the immediate surroundings of man. He adapts and relates the structure-form-position of objects to man and to other objects of man's surroundings. While the architect deals primarily with gross relationships—the individual, the group and the community—establishing over-all patterns, the industrial designer works within the patterns, filling out the details. Both he and the architect are concerned not only with the laboratory or conditional efficiency but even more with over-all efficiency on the human level. By this we mean that the lumen-per-watt efficiency of an electric lamp is important but not as important as is the total relationship of the lamp, the lighting and the room, itself, to man. It is the quality of an environment we are concerned about. Intangible as this may seem, it is the decisive factor that determines the structure-form-position of our man-made objects. This quality of our surroundings is not measurable with instruments, but we can experience it in our daily living, not always immediately, but finally.

All this does not mean that the industrial designer avoids the use of measurement and instruments. He welcomes them to guide him but not to decide for him. It also does not mean that the industrial designer decides on the forms and shapes of our surroundings on the basis of his personal prejudice. But today he has to rely mainly on his practical experience in the field. Always starting from scratch, each designer builds up his own methods and criteria for designing. His predecessors do not provide him with a basis that, in turn, he may use and advance.

The industrial designer has formulated no general theory that might guide him and only relatively little data that might support his decisions. His is a very young profession in the process of establishing itself, formulating a program and developing a methodology. Only in recent years has the designer begun to use terms like analysis and research. Even now, when not applied to determining the shape of a particular object, these terms are often used rather vaguely. Only a very little research work of a general nature is being done. Additional research covering certain aspects of designing would aid in the solution of a wide range of problems. Industrial design deals primarily with mass production. But mass production is not the duplication of an object conceived by an individual and tailored to his own need or a fad. A single produced object has little consequence; but, as the production increases, the responsibility of the designer also increases, not only moneywise, because of the enormous production cost, but also because of the impact mass production has on our civilization.

To meet his responsibilities in the fullest possible measure, the designer needs tools that will help him make objective decisions on form and shape and minimize the tendency to decide on the basis of personal prejudice. Such tools can be developed only through research.

The initial stage in the development of Industrial Design is over—the times when spectacular and very often grotesque shapes were produced merely on the whim of an individual designer. Next came a time of repeating and expanding. Now we are beginning to ask more precise questions, and increasingly more precise answers will be demanded. Research is inevitable. First there will be more intense study of individual situations. From here the field will broaden to include the various aspects of our environment. Detailed study of the object-to-man and the object-to-object relationships will come about, as will study of the historical development of objects. Correlated to these studies will be the analysis and development of a design process calculated to eliminate the deficiencies and inconsistencies of current design methods.

* * * * *

Generally speaking, this article must be a statement of intent rather than a description of accomplishment. The Industrial Design-Architecture-Planning field is one which has been too often obscured by the galloping technological developments of the early twentieth century, but whose vital importance is becoming more and more obvious as men without these arts fail repeatedly to adjust themselves to their haphazardly created physical surroundings and to the exigencies of group living. We must re-establish a sound, creative relationship between man and his physical environment. The School of Architecture is now in a position to contribute more positively than in the past toward this re-establishment.

ELECTRON DIFFRACTION

Continued from Page 8

faces of a cube meeting at the origin. A straight line from the origin through a given point with coordinates *u*, *v* and *w* is known as the [*uvw*] direction and is enclosed in brackets to avoid confusion with the Miller indices. In a cubic crystal a [*uvw*] direction is perpendicular to a (*uvw*) set of planes.

Suppose we now consider a simplified explanation of the mechanism of electron diffraction. If a beam of electrons strikes a crystal lattice it is likely that there will be a set of planes arranged so that two small portions of the beam will be reflected by adjacent planes as shown schematically in Figure 1. Let our incident beams be A and B and the reflected beams A′ and B′. If the angle of reflection is such that the path difference between AA′ and BB′ is an integral number of electron wave lengths, reinforcement will occur, and similar reflections from parallel planes in the crystal will produce a spot on the photographic plate at point P. Of course there will be other spots at different angles to the beam axis because of different orders of reflection from other sets of planes. If we now consider that the beam is passing through a thin film of material containing a large number of these crystals randomly oriented, there will be a number of crystals arranged to give selective reflection at the same angle, but they will be rotated about the beam axis; therefore, the combined spots from all crystals will produce a ring. The undiffracted part of the beam will form a spot in the center of this ring system, and the distance *d* between atomic planes can be determined from the radii of the rings *r* by the relation $d = \frac{\lambda}{r}$, where *s* is the specimen to plate distance. This is a modified form of the well-known Bragg relation considering first-order reflections only. In practice, the number of rings appearing will be modified by an effect known as the structure factor. In crystal structures more complicated than the simple cubic, some reflections will be accentuated and others eliminated by interference between different scattering centers in the same crystal.

The basic theory accounting for electron diffraction is an extension into three dimensions of the theory behind line gratings as applied in optics. A further analogy might be drawn in consideration of the resolving power encountered in electron diffraction. If the sample at which the beam of electrons is directed is composed of very small individual crystals, the pattern obtained will have broad, diffuse lines because of the small number of cooperating planes in the crystal. Similarly, if the number of lines in an optical grating is reduced to say 20 or 30, the spectral lines will become broad and fuzzy. This effect may also give some indication of the order of grain size by measurement of the widths of the rings in the pattern. If the crystals in the sample are rather large, there will be only a few in the area covered by the beam, and a sharp, spotty pattern will result. If the crystal is large enough to occupy the entire beam area, the pattern may consist of many fine lines at different angles to each other. This effect was first noticed by Kikuchi, and the lines are named after him. Experimenters are not wholly in accord with his explanation of their cause, but it is generally agreed that they are due to coherent scattering from entire net planes in the crystal.

Diffraction Cameras

Since electron diffraction is still fairly new as a method of investigation, experimenters customarily built their own diffraction cameras until about seven or eight years ago. However, in recent years RCA, General Electric, North American Philips and others have begun to manufacture them. Diffraction cameras may be divided into two main groups by whether they employ high-voltage or low-voltage electrons. The high-voltage cameras might be further subdivided into those intended for work with nonvolatile solids and those for work with gases. Low-voltage cameras will not be considered here since they are not presently used in practical investigation.

In high-voltage cameras there are several different means of obtaining electrons. The source can be a gas-filled discharge tube, a hot-cathode high-vacuum gun or a cold-cathode gun. The accelerating potential can be obtained from a high-voltage supply similar to that used in x-ray equipment. Some workers use a spark gap to measure the voltage, but the present trend is to calculate the voltage by working backward from data obtained by electron diffraction measurements on a known sample. The camera manufactured by RCA utilizes a compact voltage tripler. When this type of supply has a carefully regulated voltage, it furnishes a good source of homogeneous electrons from a hot-cathode emitter. If a gas-discharge tube is used, some type of filter must be employed. The usual filter consists of mechanical stops combined with either electric or magnetic fields.

With high-voltage cameras photographic plates are the universal means of recording the pattern. The electrons form the image directly without any recourse to fluorescent screens as in medical radiography.

Some provision must be made for adjusting the specimen while it is in the camera and under vacuum. There must be motion into and out of the beam, variation of the angle of incidence and rotation in azimuth. This can be provided mechanically through neoprene seals lubricated with octoil and graphite.

Specimens that are poor conductors of electricity have a tendency to develop a positive charge when struck by electrons at a glancing incidence. This charge is caused by secondary emission of electrons when the specimen is bombarded by the high-voltage beam. If the effect cannot be neutralized, it will cause distortion of the pattern. The surest way to control this effect at all times is to have a secondary source of low-voltage electrons with which to spray the specimen and neutralize the positive charge. However, this technique can lead to other troubles. Observations at Georgia Tech have indicated that low-voltage electrons tend to cause oil vapor from the diffusion pump to deposit on the surface of the specimen after a short period of time, obscuring the pattern of the true surface. The instrument used was an RCA Type EMU Electron Microscope with diffraction adapter and RCA charge neutralizer. A small, clean sample of polished glass was placed in the diffraction camera and examined by the reflection tech-

niques described later. At first no pattern was visible, but after a few minutes a diffuse pattern appeared. Another piece of glass which had been coated with a sample of the pump oil was examined, and its pattern was found to be very similar to the first pattern. Oil deposition may be minimized by judicious use of the charge-neutralizing equipment or a liquid-air trap on the diffusion pump.

A diffusion pump backed up by a mechanical pump is the standard method of obtaining high vacuum in all dynamic systems. In equipment designed for obtaining patterns from gases, the gas is admitted through a controllable leak directly in the path of the beam. The pumping system operates rapidly enough to maintain sufficient vacuum in spite of the leak.

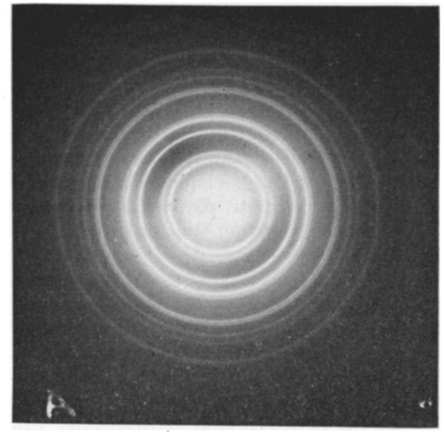

Figure 2. Electron diffraction pattern from an evaporated gold film.

Transmission Patterns

The patterns produced when electrons are diffracted by passage through a crystalline structure are called transmission patterns. They may consist of circles, arcs, spots, lines or diffuse patches, appearing singly or in combination. As explained previously, a powder of small crystals randomly oriented will produce a ring pattern. If the crystals are small the ring will be diffuse; if they are large the ring will appear spotty. It will often be noted, especially in thin metal films, that the rings may appear to be divided into arcs. This indicates that a certain number of particles have one principal axis in a preferred, or common direction. However, the orientation about this preferred direction is random. Such materials are said to show fibering or fiber structure. If the fiber axis is parallel with the incident beam the specimen must be tilted to detect the orientation. The orientation is designated by specifying the direction of the axis of the crystals; for example, a [111] orientation in cubic crystals implies that a (111) plane of all the crystals lies in the plane of the surface.

The interatomic spacing of the crystal planes, or d values, may be found by measuring the radii of the rings in the pattern. It is much easier if the crystal structure of the material is known first. In cases where the crystal structure is more complicated than the simple cubic, the reflections that will be accentuated or eliminated by interference can be determined from available tables. It is common practice to take a pattern of a known material such as magnesium oxide and use it for a standard of measurement. The d value will then be $d = \frac{K}{r}$, where r is the measured ring radius and K is a constant which lumps together the geometry of the diffraction camera and the wave length of the electrons.

Some metals may be examined by depositing them on a thin substrate in a high vacuum. The specimen should be no thicker than a few hundred angstroms depending upon its density. A pattern obtained from an evaporated gold film is shown in Figure 2. A thin parlodion substrate supported the gold film in this case.

Transmission patterns of powdered materials can be obtained by dispersing them on a substrate. The material is suspended in a suitable liquid in which it is insoluble, and a few drops of the suspension are allowed to dry on the substrate. A layer of sufficient thickness to yield a good pattern can be built up by trial and error. In some cases the particles may have a layer on them which furnishes a pattern so that their true nature is not determined. This makes it advisable to check electron diffraction results against x-ray diffraction where possible, since x-rays penetrate more deeply than electrons.

In checking *d* values by measurements of the ring radii, use is often made of Ewald's concept of the reciprocal lattice.[3] Instead of considering different orders of reflection as allowed for by the *n* in the Bragg formula, each order (2, 3, 4, etc.) is considered as coming from fictitious planes having ½, ⅓, ¼, etc., the interplanar spacing of the plane in question.

Pattern interpretation, especially in the case of evaporated films, is often complicated by the appearance of extra rings which cannot be correlated with known facts about the sample. These are usually spaced inside the prominent rings and are due to adsorbed gas in the crystal lattice. They can often be eliminated by careful outgassing in a vacuum or by heating the sample.

Reflection Patterns

Materials too thick for transmission of the electron beam can be made to yield what are called reflection electron diffraction patterns. These are made by causing the electron beam to fall on the specimen's surface at grazing incidence. A pattern is formed, not by reflection from the surface as the name might suggest, but rather by transmission of the beam through tiny irregularities projecting from the surface. The nature of these irregularities has much effect on the appearance of the pattern. If they are sharp and roughly pyramidal, the electrons passing through the upper portions will be elastically scattered and will form a pattern, while those passing through the lower portions will be inelastically scattered and will contribute to the background. If the projections are round-topped, the scattering will be primarily incoherent, and the pattern will be weak or will fail to show up at all. Reflection patterns are similar in appearance to those made by the transmission technique. However, since the opaque specimen shields the photographic plate from part of the beam, only half of the pattern is obtained.

As implied above, the value of the reflection technique lies in the information it can often give concerning the nature of surfaces. It is not limited to specimens thin enough to transmit electron beams, and any solid object can be examined by this technique provided the surface is properly prepared. The preparation of samples requires care, since even slight contamination on the surface will yield a pattern which will mask the true pattern. A specimen left exposed in a laboratory for an hour or so may accumulate a coating of grease sufficient to affect the pattern. Flat surfaces are usually prepared by grinding, chemical etching or electrolytic action.

The technique of interpreting reflection patterns is similar to that for transmission unless orientation is present. If a thin film has a fiber structure normal to the surface, the fiber axis will be parallel to a transmitted beam of electrons but will be perpendicular to a reflected beam. The reflection pattern will show arcs along the rings according to the degree and type of orientation, but the transmission pattern of the same specimen will show no orientation unless the film is tilted. As mentioned, a reflection pattern indicates only the surface orientation, whereas a transmission pattern reveals the total orientation throughout the volume.

Changes in grain size are indicated by the widths of the rings in a reflection pattern. However, the exact size of the grains cannot be determined. Since the beam is directed along the surface of the specimen, there is no exact specimen-to-plate distance.

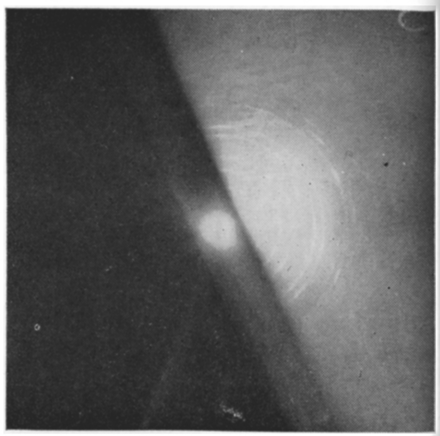

Figure 3. The arcs in this reflection pattern of a thin film show [100] orientation.

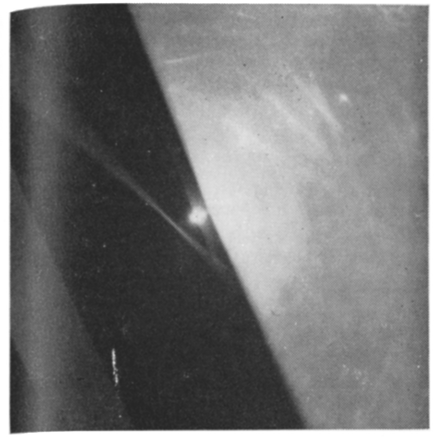

Figure 4. Kikuchi lines due to coherent scattering from entire net planes.

This fact is responsible for some broadening of the rings.

An example of orientation in a face-centered-cubic crystal is shown in Figure 3. The pattern, made by reflection from the face of a thin platinum film exhibits pronounced [100] orientation.

Figure 4 shows the Kikuchi lines and spots obtained from the face of a ground and etched radio frequency oscillator crystal.

Applications

Practical application of electron diffraction to research problems is still a rather new field, and its potentialities have not yet been fully realized. X-ray crystal analysis and electron diffraction should be regarded as complementary; the former finds its greatest use in the examination of material in bulk, while the latter is a highly useful method of investigating very thin films on the surface of materials.

Electron diffraction has enabled investigators to determine the orientation of the long-chain molecules in greases on solid or liquid surfaces. Orientation of the grease molecules indicates a strong attractive force between the substrate and the grease, so that the oils and greases showing the most marked orientation are least likely to be squeezed out from the bearing surfaces by pressure. Observations have indicated that the higher the molecular weight the more likely the oil is to orientate. Thus, extreme-pressure performance in greases might be expected to increase with increase in the molecular weight of their constituents.

Jenkins[2] used electron diffraction to study the mechanism of graphite lubrication and to compare the properties of graphite and amorphous carbon. He found that the graphite crystals tend to align themselves on a bearing surface to provide a smooth, low-friction layer. In some cases they actually become enmeshed in the structure of the metal as revealed by extra lines in a diffraction pattern of the surface. This phenomenon is one of the reasons for the so-called self-lubricating properties of cast iron.

Considerable work has been done to find out what happens to the surface of a metal when it is polished. It was once believed that polishing was merely a procedure of leveling the minute irregularities of a surface. However, electron diffraction has presented evidence that the surface becomes amorphous under the pressure of the polishing material. All polished metal surfaces seem to exhibit the same diffraction pattern, namely, the two orders of diffraction from a predominating spacing representing the least distance of approach of the atoms. By progressively sputtering off the metal and making diffraction patterns the depth of this apparently amorphous layer has been determined.

A field open for investigation is the study of oxide layers on metal surfaces. Although zinc oxide normally has a hexagonal structure, it has been found that the unit cell is modified when polycrystalline zinc is exposed to oxygen at room temperature. The plane of the unit cell in contact with the zinc surface contracts to conform to the zinc spacing, and the hexagonal axis increases to maintain a constant unit-cell volume. When heated, the modified oxide breaks down into smaller crystals of normal zinc oxide. This exposes the surface and allows more of the abnormal oxide to form.

One rather special application to electron diffraction is determination of the inner potential of crystal structures. Although a crystal is made up of equal positive and negative charges, its potential differs from that of free space because, as a result of the atomic arrangement, these charges are not uniformly distributed. This potential causes the crystal to have a refractive index for electrons, and measurement of this index along different planes gives information as to the magnitude of the potential.

Only a few of the present uses of electron diffraction have been described here, and new applications may be expected to develop as the field matures. Even now it seems safe to say that electron diffraction is becoming a standard technique for industrial research.

BIBLIOGRAPHY

1. Davisson, C. and Germer, L. H., "Diffraction of Electrons by a Nickel Crystal," *Physical Review 30*, 707 (1927).
2. Jenkins, R. O., "Electron Diffraction Experiments with Graphite and Carbon Surfaces," *Philosophical Magazine 17*, 457 (1934).
3. Sproull, W. T., *X-Rays in Practice*, McGraw-Hill, New York, 1946.
4. Thompson, G. P. and Reid, A., "Diffraction of Cathode Rays by a Thin Film," *Nature 119*, 890 (1927).

SOME RECENT DEVELOPMENTS IN READING

Continued from Page 6

to recognize the individual letters and words composing the thought unit. He sees groups of words according to meaning rather than individual letters and words.

Samuel Renshaw of Ohio State University has published an interesting account of practice with the tachistoscope as an aid to teaching reading skills. At Battelle Memorial Institute he conducted a class two training periods a week for fifteen weeks. Students were adults—mostly chemists, physicists, and engineers. Each session included exposure with the tachistoscope of about twenty-five slides containing mostly numbers of from five to nine digits. Some slides with words and geometric forms were used. Time of exposure ranged from 0.1 to 0.01 second. Two forms of a standardized reading test were used with the group. These tests showed an average gain of 33 percentile ranks in comprehension; the class average moved from the 52nd to the 85th percentile. The average reading rate increased from the 44th to the 71st percentile.[2]

Another interesting experiment in reading training was conducted at the Air University, Maxwell Air Force Base, Alabama. The training there included work with both the tachistoscope and the reading accelerator. Ninety Air Force officers were studied, and the training period lasted for eighteen hours over a period of several weeks. After the training, their scores on the Educational Advisory Staff reading-speed selections indicated an average increase in rate from 291 words per minute to 460 words per minute, or a gain of 58 per cent. Scores on the comprehension test showed an average increase of 7 per cent.[3]

In a course conducted at the Georgia Institute of Technology since 1949, similar gains have been achieved. Two forms of a standardized test of general reading efficiency reveal an average increase of 12.5 per cent in percentile rating. On speed tests the average increase in rate of reading ranged from 30 per cent to 81 per cent in different school quarters, with no over-all change of significance in comprehension.

With the aim of teaching the student to read more efficiently, the course at Georgia Tech makes a two-fold approach to the problem of reading. It attempts to make the reading process easier by systematic practice in acquiring efficient physical habits, and at the same time it acquaints the student with tangible methods by which he can improve the quality of his comprehension. Various mechanical aids—the Harvard films, the reading accelerator, and the tachistoscope—are used. In addition, a textbook containing exercises in comprehension is used by each student. This course meets two hours each week for about ten weeks. It is open to any student on the campus as an elective carrying no college credit.

A fact that is emphasized quite strongly in the Tech course is that a reader should develop flexibility in his reading habits. A person should not read all material at the same rate and in the same manner. He should be able to read rapidly when fast reading is desirable. Difficulty of the material, the purpose for which the reading is being done, and a number of other factors should determine the rate of reading as well as the whole pattern of reading habits.

Contrary to much popular opinion, the student's comprehension usually does not decrease when he systematically trains himself to read faster. Actually, in most cases it stays about the same or even improves. This fact is understandable when one realizes that the rapid reader reads easily; since the mechanics of reading are not difficult and tedious for him, he is able to give his concentrated attention to getting the meaning from the reading. Furthermore, since the fast reader sees the words in groups rather than as single units, he has less trouble than the word reader in determining relationships and in assembling the parts so as to comprehend the complete ideas being presented by the author.

All these developments in reading should be of immense interest to busy people in business and professional life today. Reading demands are becoming increasingly heavy, and the person who desires to do his job more efficiently will want to know how time-saving methods can be applied to his reading. Further, he will want to avail himself of training in these methods, so that the time he saves in essential reading can be profitably applied to his other duties.

REFERENCES

1. "Executives Back to School," *Business Week*, April 5, 1952, pp. 78-80.
2. Samuel Renshaw, "The Visual Perception and Reproduction of Forms by Tachistoscopic Methods," *Journal of Psychology 20*, 223-4, July, 1945.
3. *The Air University Reading Improvement Program*, The Air University, Montgomery, Alabama, 1948, pp. 21, 23.

PERMEABILITY OF PARACHUTE FABRICS

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parachute fabrics will be simulated and studied in this phase of the work. It is expected that measurements for a given run will be carried out in about forty seconds.

Experimental Work

In order to eliminate some of the many variables that affect the permeability of fabrics, special nylon, Orlon and Dacron cloths have been woven in Georgia Tech's A. French Textile School, using yarns of different denier (weight) and various weave patterns. Under the direction of Prof. Gerald B. Fletcher, the sample fabrics have all been woven under controlled humidity, using the same warp, same loom and same operators.

The low-pressure phases of the permeability tests were conducted under the direction of Dr. M. J. Goglia of the School of Mechanical Engineering, who also has worked on the development of means for the analytical study of air flow through cloths, a field in which there is little background information. His application of theories involving flow through porous media has considerably advanced our knowledge of the mechanics of the air permeability of fabrics. Some success has been achieved in determining a factor to use to characterize the geometry of fabrics. It is hoped that determination of a "characteristic length" analogous to the pipe diameter used in conventional applications of the Reynolds' Number will permit calculation of fabric permeability on a basis similar to that used in the fields of fluid flow and aerodynamics.

Our study of the geometric variations of fabrics and our attempts to determine "characteristic lengths" have been greatly facilitated by the work of Prof. LeRoy Woodward of the Station's Electron and Optical Microscopy Laboratories, who has made numerous photomicrographs of various test fabrics. One such photomicrograph is shown on the cover. While it did not provide quantitative data, his study of interstitial variations with a stereoscopic microscope proved very valuable in formulating ideas of the mechanics of air flow through fabrics.

The fabric permeability investigation has been complicated by the fact that the effects of some 23 variables must be considered, such as non-uniformity of weaving, variations in humidity, the time rate of load application, etc. A statistical study to determine the number of samples of a given fabric that should be tested in order to obtain an experimentally determined mean value closely approximating its true average permeability was conducted by Dr. Joseph J. Moder, Associate Professor of Industrial Engineering. He found that testing of 9 random samples of an individual fabric yields a mean permeability value within 7 per cent of the true average 95 per cent of the time.

Since the over-all investigation is continuing, no attempt will be made here to present the data obtained to date or to draw conclusions from them. Analysis of the results obtained from the low-pressure testing of fabrics woven at Georgia Tech is nearing completion. As mentioned, series of tests will be conducted at much higher pressures to simulate the rigorous conditions encountered in Air Force use.

While the parachute designer's ultimate choice of nylon, Orlon or Dacron fabric will probably be made on the basis of properties other than air permeability, the Georgia Tech work is expected to prove of substantial aid to him. By providing information on the factors determining the permeability of fabrics made from the various synthetic fibers available, this research will permit the establishment of categories of fibers from which the parachute designer may choose, specifying the permeability he desires. The mill will then have the information necessary to produce a cloth of the proper construction to meet the designer's permeability specification.

STARS, PIGS AND RESEARCH

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ting radiations which, on some wave lengths, exceed those of the Sun in intensity.

Truly, Man has had to be ingenious to find out as much as he now knows of natural phenomena and to utilize those native to the Earth to his own advantage. Even accidental discoveries, such as Charles Lamb's version of how the Chinese learned to roast pig, required clever reasoning as to cause and effect. Many, probably most, of Man's discoveries and nearly all of the practical applications of them have come as the result of his conscious or unconscious use of the methods of research.

We know that ancient men looked, saw and pondered. From the mathematics and other arts they gave us, we know they reasoned well. Why then no steamship or motor car until the 19th Century and no airplane or nuclear energy pile until the 20th? If the Grecian age had produced more Heros of Alexandria or the Renaissance more Leonardos, the age of the machine might have arrived centuries earlier. However, great as was the Greeks' power to hypothesize, their belief that experimentation was undignified prevented testing of their theories, rejection of those that were fallacious and application of those that were valid. It remained for Bacon, Galileo, Harvey, Newton and their like to demonstrate the value of experimentation and thereby add "verify" and "apply" to "look," "see" and "ponder."

Experimental research has made television and human flight commonplace in our time. Scientists in countless laboratories of colleges and universities, industries and governments are working to bring us new marvels to surpass the realities of today. If and when Man lifts himself from his pebble to venture forth among first the planets and then the stars, experimental research will have made it possible.

The practical minded may well ask: Why a desire for space travel? What good could come of it? Any attempt to answer these questions completely now would only reveal the lack of knowledge which is the main reason for wanting to explore outer space. No one knows what all may exist out there—new forms of matter, perhaps other kinds of life. Obviously we cannot predict what value future discoveries may come to have before we know what will be discovered. However, past experience indicates that applied research soon finds useful applications for new knowledge, even though it may come from the purest of research.

Both pure and applied research rely upon experimentation, the first to supply data and support theories, the second to put freshly won knowledge to practical use. Compelled by the desire for knowledge and the power it brings to mold his destiny, Man may be expected to find, comprehend and use more things than are dreamt of in our present philosophy.