Edited In Retrospect

Ideas for ID

• Earlier in the year, the Industrial Development Branch of Georgia Tech's Engineering Experiment Station released a brand-new bimonthly publication called *IDeas*. The big idea behind *IDeas* is to pinpoint needs and disseminate research findings which can solve State and local problems in industrial development.

The initial issue featured a proposed 10-point program for the development of industry in Georgia. Based on 18 months of basic and applied research, the closely-related 10-points of the program are all considered essential by the Tech research group if the State's urgent and long-ranged industrial needs are to be met.

Key point in the program was the suggestion that an independent, non-political committee of business and industrial leaders be formed to provide a central, authoritative body which could concentrate on the elimination of existing weaknesses. This committee would also serve to add prestige to the State's drive for a more prosperous economy through industrial development.

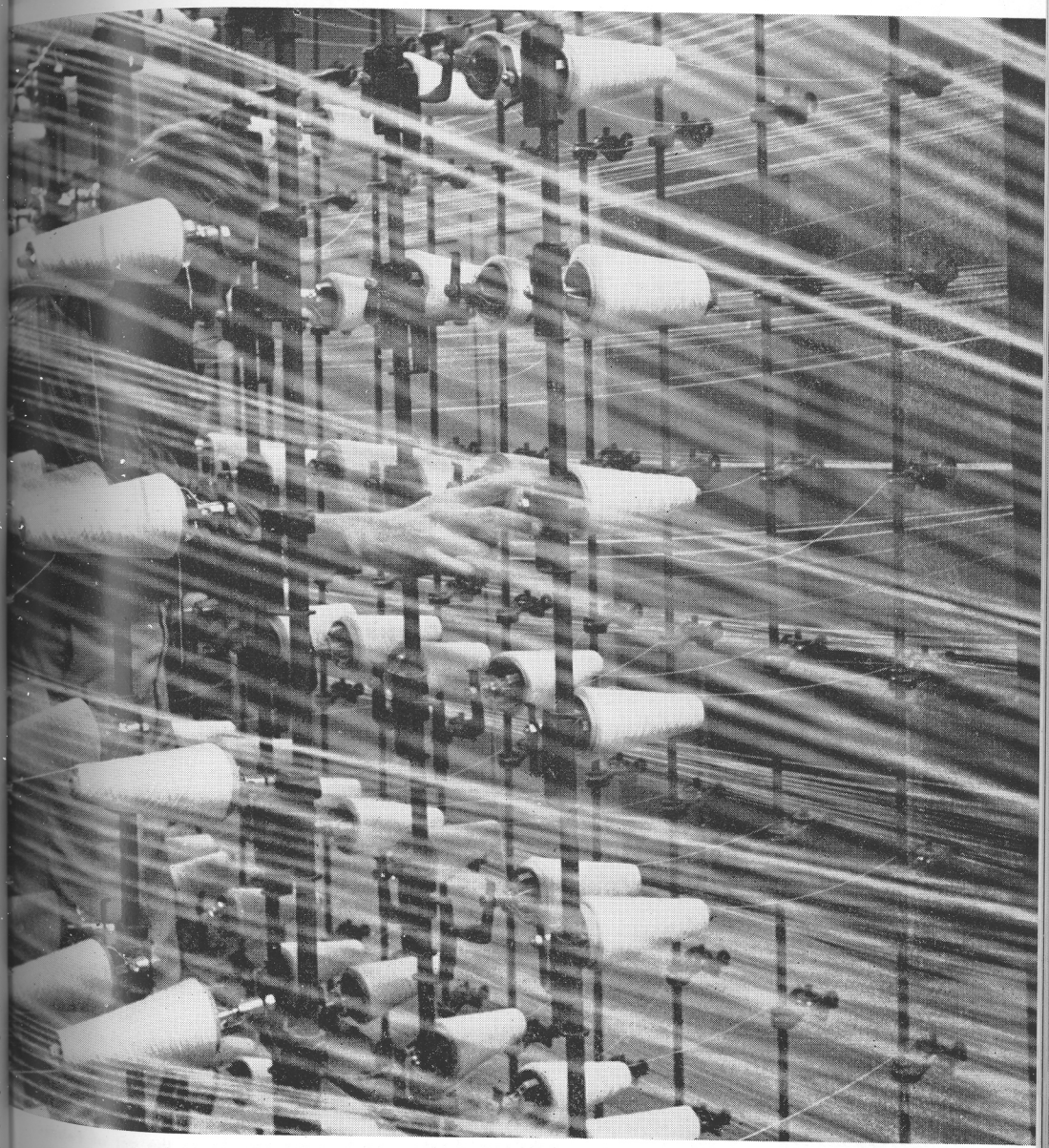
Briefly, the other points in the optimum program prepared at the request of Governor Griffin are: (1) organization of a special *rural development* research group, (2) a greatly expanded market research program, (3) establishment of a metal resources research program, (4) establishment of a forest products research program, (5) an accelerated program of economic feasibility studies to present *packaged* analyses to industrial prospects, (6) expansion of spot analysis and consulting services, (7) aid to local development groups in setting up and carrying out effective action programs, (8) a manpower research program on the State's present and future labor supply, training needs and related problems, and (9) a basic data reservoir and *clearing house* to make available quickly, yet completely, data needed for industrial prospects.

Future issues of *IDeas* will report on research findings and analyze some of the State's economic problems in detail. You may receive free copies of *IDeas* by writing to: Publications Office, Georgia Tech, Atlanta 13, Georgia.

JULY, 1958

The Research Engineer

Published by the Georgia Tech Engineering Experiment Station



SPECIAL TEXTILE ISSUE

The Research Engineer

VOLUME 13, NO. 3 JULY, 1958

Published quarterly by the Engineering Experiment Station
Georgia Institute of Technology, Atlanta, Georgia

contents

the cover

The machinery shown on the cover and again on page 4 of this issue is a warper creel, one of the many items of industrial equipment in the laboratories of Georgia Tech's School of Textile Engineering. In the cover photo a student, almost lost in the intricate webs of yarn, makes an adjustment in the tension of a cone. Experience in the practical operation of full-scale industrial machinery is only one of the excellent features of the textile curriculum at Tech. The full story of how the Textile School has been built up into one of the finest in the nation begins on page 5.

The cover and all photographs in this issue by Bill Diehl, Jr.

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

The President's Page

AT A TIME when education and research have dramatically become areas of great national concern, it seems especially appropriate to take a look at what one industry can do for one school. Unique on the Georgia Tech campus is the strong financial support that the School of Textile Engineering has been receiving since 1943 from its parent industry.

The medium for this support is the Textile Education Foundation, a non-profit organization supported by a group of far-sighted Georgia firms that realize the value of education and research to their industry. In its first 15 years this Foundation—described in more detail in the article beginning on page 5 of this issue—has made available to Tech's Textile School $650,000 in funds and equipment. And this support is continuing at the rate of $35,000 a year.

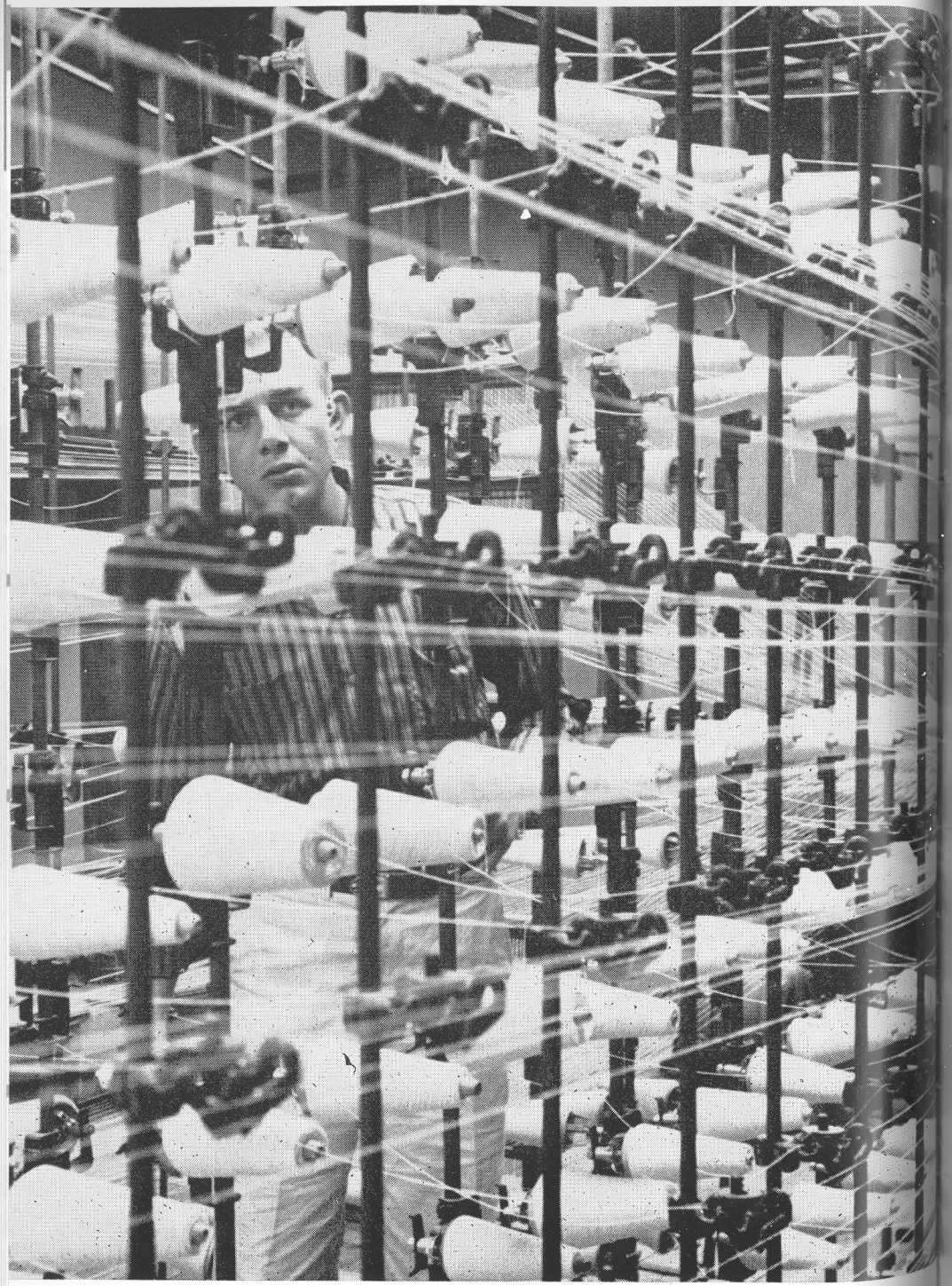
Part of this money was used to initiate the first salary supplementation program on the campus—a program which, in a great measure, has accounted for Tech's reputation as one of the country's best textile schools.

Through one of its committees, the Foundation also has been engaged in an active program to help recruit outstanding graduate and undergraduate students for Georgia Tech.

In my first year at Georgia Tech I have learned that the leadership of this Foundation in its administration of funds has been consistently wise and effective. The result has been the growth of an outstanding school and research organization to serve the State and the region as well as a rewarding return on the investment—in terms of trained manpower and technical advance—for the textile industry.

The work of the Textile Education Foundation continues to be an impressive example of active industrial interest and faith in higher education as well as an example of good common sense, a combination extremely difficult to beat.

E. D. Harrison
President



"ANGELS" OF EDUCATION

Georgia Textile Firms Offer a Strong Case for Industrial Support of Education and Research in the Working Example at Georgia Tech

IN ITS HISTORY, Georgia Tech has had no more enthusiastic supporter than the state's number one industry, textiles. From the beginning of the A. French Textile School in 1899, the industry (as a group and as individual companies) has offered Tech a great amount of financial, political, and moral support.

As the state's largest single taxpayer, the textile industry has furnished a large amount of funds that eventually have been used to support Georgia Tech. But it was the formation of a non-profit educational foundation—the Textile Education Foundation, Inc.—in 1943 that really stamped the textile industry as Tech's number one supporter, as well as Georgia's number one industry.

The Textile Education Foundation, Inc., was founded by the Cotton Manufacturers' Association of Georgia on August 27, 1943, in Atlanta. According to the charter petition, the general nature of the new corporation was as follows:

"This corporation shall be organized and operated exclusively for charitable, scientific, literary, and educational purposes, and no part of its earnings shall inure to the benefit of any private shareholder or individual and no substantial part of its activities shall be carrying on propaganda or otherwise attempting to influence legislation. The corporation is formed for the purpose of aiding and promoting, by financial assistance or otherwise, from the income and principal of its assets, all types of textile education and research at any educational institution or institutions which have the status of charitable or educational institutions to which gifts may be made that qualify as charitable or educational gifts under the United States Internal Revenue Code. The corporation shall have the power to receive gifts, bequests and devises, and to purchase, own, hold and sell real and personal property of every kind and character, to pay in full or to supplement the salaries of members of the faculty of such institutions which are engaged in work of textile education or research; to donate all or any part of the equipment, plant, facilities and materials incident to such textile education and research, to make gifts to such institutions for the endowment of such educational research, and to do any and all things that may seem proper to promote and improve textile education and research at any such institution. The corporation shall be a non-profit charitable and educational corporation."

To finance this program, textile manufacturing companies in Georgia originally subscribed $500,000 to be administered by a Board of Directors elected by members of the new corporation. (The membership was limited to those listed on the charter plus persons, firms or

Continued on page 6

corporations making subsequent contributions to the Foundation.) Under the charter, the Board of Directors may, at their discretion, expend both the interest and the principal of the fund to carry out the original purpose of the Foundation. Despite the fact that it must be assumed that the Foundation was created for the primary purpose of assisting the A. French Textile School, the corporation was established so as to enable the directors to render assistance to any qualified textile school.

Since its inception, the Textile Education Foundation has been directed mainly by Tech graduates. This year's president is John P. Baum, a 1924 Textile Engineering graduate who is now vice president of J. P. Stevens, Inc., in Milledgeville, Georgia. His predecessor was B. W. Whorton, class of 1927, of LaGrange.

Tech Graduate Conceives the Idea

Credit for the organization of this important supporting arm of Georgia Tech should go in a very large part to Julian Hightower, a 1909 Textile Engineering graduate. While serving as president of the Cotton Manufacturers' Association of Georgia in 1942, Mr. Hightower conceived the idea of such an educational foundation and furnished the inspiration which brought about the first organization efforts.

At that time, Mr. Hightower and several other textile executives through the state felt that such a foundation would be a great aid in an effort to train more graduate textile engineers through a better and more practical educational program. They felt — and events proved them correct in their supposition — that there would be a great scarcity of technically-trained young men qualified to fill positions of supervision in the industry. Those who sponsored this program hoped that by providing more modern and efficient facilities, by enlarging the training capacity of the textile school, by supplementing the staff of teachers and instructors, by broadening and making more practical the courses of study and by providing funds for other specified purposes, a larger number of better-trained engineering graduates would be available to help meet the highly competitive conditions expected in the industry after the war. A great deal of this worry about the post-war state of the industry was brought about from the failure of the War Manpower Commission to provide selective service deferment—such as was allowed for other types of engineering—for textile engineering students. This situation practically suspended operations of the Nation's textile schools during World War II.

After Julian Hightower had convinced other textile leaders in the state of the importance of this educational program, he appointed a committee of Georgia executives to start the fund-raising campaign. This group elected his brother, the late W. Harrison Hightower, as chairman. Together, the two brothers did a magnificent job in raising the funds within a short time.

The air-conditioned, humidity-controlled weaving laboratory, showing Draper E- and K-model looms. The yarn, supplies and many of these machines were donated by the Foundation.

It Has Helped Tech in Many Ways

The importance of this Foundation to Tech's progress in the textile field can be seen by the fact that in its first twelve years of assistance, this Foundation has given Tech's textile school over $650,000 in funds and machinery. At the present time, the Textile Education Foundation is making available $35,000 a year to Tech's textile school for faculty salary supplementation, student scholarships, and other contingencies. In addition, the enrollment committee of the Foundation under the chairmanship of John P. Baum has been very active in trying to recruit outstanding students for Tech's textile school.

Today, mainly because of the efforts of this Foundation, Tech has facilities for textile education equal to any in the country. The A. French Textile School is housed in the $1,500,000 W. Harrison Hightower Building, one of the outstanding buildings on the Tech campus. This modern three-story structure, functionally-designed to serve every need of the textile student, is equipped with nearly $800,000 worth of laboratory and mill equipment. Its faculty and curricula have won it wide recognition as one of the Nation's foremost schools of textile education.

With the continued strong support of the Textile Foundation, the textile school should continue to grow and thrive.

Students in Weaving Lab receive detailed explanation of loom set-up and adjustment.

Textile Education at Tech Means Years of Chemical and Mechanical Theory, Plus Practice with Modern Equipment

How to Teach Textiles — a Case Study

by J. W. McCARTY, Associate Professor, School of Textile Engineering

THE A. FRENCH TEXTILE SCHOOL — although one of Georgia Tech's oldest degree granting schools—has constantly remained young in ideas and equipment. Today, it is recognized as one of the most modern and outstanding schools for textile education in the United States.

An act of the Georgia Legislature in 1899 established the school after Mr. Aaron French, a Pittsburgh, Pennsylvania philanthropist, offered to donate a large part of the funds needed for the construction of such a school. As a result of Mr. French's generous contributions, the school was named in his honor.

In 1947, the Governor of Georgia authorized funds for a new building to house the school. As a result, the A. French Textile School moved into its new $1 million building in 1949. By the time the construction began, the textile industry, through the Cotton Manufacturers' Association of Georgia, had raised a sizable sum of money for the specific purpose of aiding textile education in the state.

These funds, administered through the Textile Education Foundation of Georgia, Inc., made possible the complete equipping of the new building. Because of this industry-wide cooperation and help, the new building was designated the Harrison Hightower Building in honor of the guiding spirit and first president of the Textile Education Foundation.

Building and Equipment

The Harrison Hightower Building was designed for a complete separation of the laboratory area from the classroom and office areas. The building contains eight classrooms, a student lounge, a graduate lounge, a conference room, a library, an air-conditioned auditorium with 300 theater-type seats, and an exhibition gallery containing 3,300 square feet of floor space (this exhibition space is available, free of charge, for the display of textile materials, textile machinery and allied products of interest to the textile student and/or textile industry).

The large laboratory area is ideally arranged for an even flow of stock from the opener room through weaving and finishing. The equipment in each laboratory has been carefully selected and arranged so that it is representative of common industry practice as well as flexible enough for both instructional and research purposes. Each laboratory is equipped with its own air-conditioning system, capable of producing a wide range of temperature and humidity.

The following special purpose laboratories are included in the building: Cotton picker room containing opening and picking equipment for the processing of cotton; synthetic picker room containing a synthetic picker with tandem hoppers and feed table; cotton card room containing carding, drawing, combing, and roving equipment; woolen card room containing a blending picker and a set of woolen cards; synthetic card room containing both flat-top and roller-top cards and drawing and roving equipment for long staple stock; cotton and woolen spinning room containing all types of long-draft spinning equipment for cotton and a woolen spinning frame; synthetic spinning and twisting room containing spinning equipment and both ring-twisting and up-twisting throwing equipment for synthetic fiber processing; cotton twisting and winding room containing specimen types of twisting and winding equipment for cotton processing; warper room for the warping of both natural and synthetic yarns; slasher room containing both a regular cotton slasher and a Callaway sample slasher; cam and dobby weaving room containing numer-

Continued on page 10

ous examples of all types of cam and dobby looms; jacquard weaving room containing jacquard looms ranging from 100 hooks to 2600 hooks; dye laboratory for the beaker dyeing of samples; dye house containing examples of the most common types of dyeing and finishing procedures; physical testing laboratory containing almost all types of testing equipment including the latest Instron electronic strain-gage type tester; chemical testing laboratory containing many specialized pieces of equipment for the determination of dyes and finishes; microscopy laboratory containing all types of microscopic equipment for use in fiber identification and study; sewing room containing representative examples of industrial sewing machines; and, design laboratory equipped for the study and creation of woven designs of various kinds.

The Curricula

From its inception, the A. French Textile School has offered a four-year course of instruction leading to a college degree. At the present time, two undergraduate degrees with three options of study are offered.

All of these undergraduate degrees may be taken under the regular plan or the co-operative plan. Under the regular plan, the student attends school during each quarter for the nine-month regular school year and may, at his option, attend during the summer quarters also. Under the co-operative plan, the student attends school and works in alternate quarters. In this way, the student may earn a portion of the money required for his education and obtain valuable experience which will aid him after graduation.

Each of these courses of study requires a basic study of textile engineering and for this purpose the textile school offers courses in yarn manufacture, weaving, dyeing and finishing, testing, costing, design and analysis, and synthetics.

The Bachelor of Textile Engineering degree, in addition to the the basic textile courses, leans heavily towards the study of basic engineering courses among which are six courses in mechanics, four courses in mechanical engineering, two courses each in electrical engineering and industrial engineering, and one course each in chemical engineering and civil engineering.

The Bachelor of Science in Textiles degree may be obtained in either of two options.

The Chemistry and Dyeing Option, in addition to the basic textile courses, requires a number of courses in the chemical sciences such as analytical chemistry, organic chemistry, physical chemistry and chemical instrumental analysis. Students in this option are also required to take two specialized textile courses in which the printing of textiles and chemical treatments for textiles are studied.

The Management Option includes a much broader basic study of textiles than is required for the other two courses of study. In addition, this option requires a number of Industrial Management courses of which the following are typical: Economics, finance survey, business law survey, accounting survey, industrial marketing, cost accounting, personnel management and industrial relations.

Scholarships

To encourage and aid students choosing Textile Engineering as a career, several scholarships are available each year to worthy students. Among these are the following specifically for textile students: Atlanta Textile Club Scholarship (for junior Textile students), Holeproof Hosiery Company Scholarship (for Marietta, Georgia High School graduates), Keever Starch Company Scholarship (open to all Textile Students), Paul A. Redmond Scholarship (restricted to residents of Alabama and Georgia), Seydel-Woodley & Company Scholarship (junior or senior), Textile Education Foundation Scholarships (five each year for entering freshmen from Georgia), and United States Rubber Company Scholarship (junior or senior). In addition to the above specifically for textile students, there are a number of other scholarships available not restricted to any particular field of study.

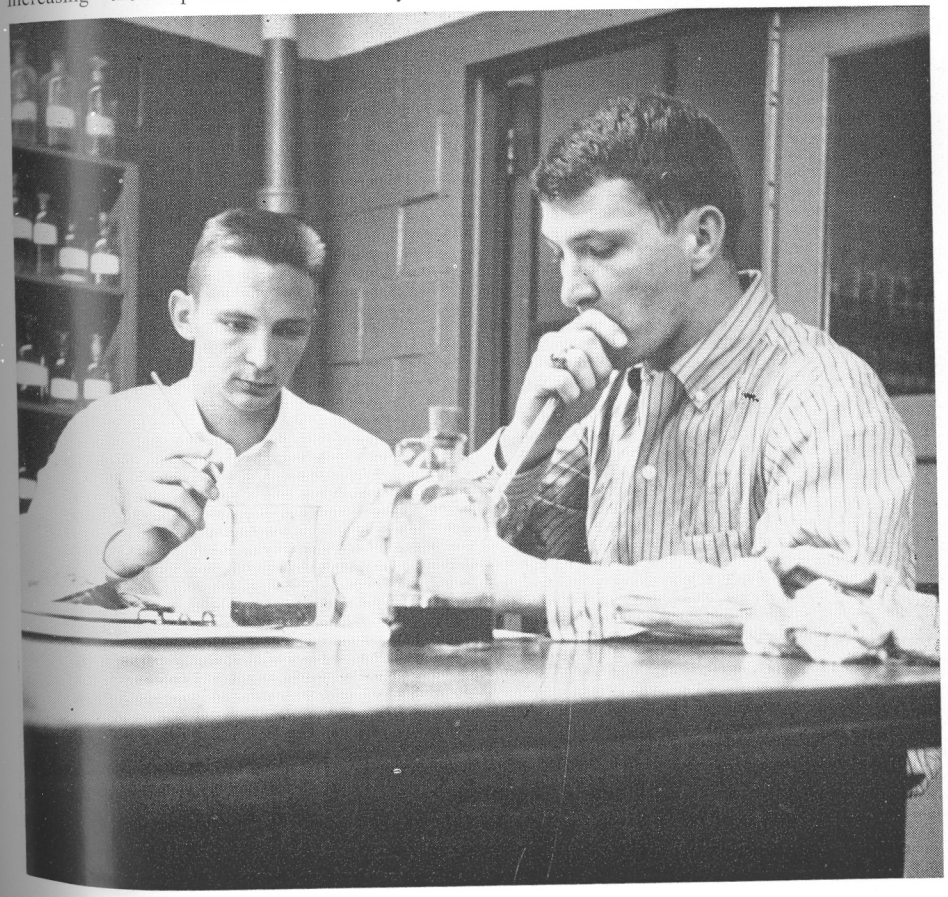
The school also has available several loan funds which are used to aid capable and worthy students in the furtherance of their educational ambitions.

The A. French Textile School also offers Master's degrees in both Textile and Textile Engineering. For this purpose, the school offers graduate level courses in yarn manufacture, weaving, dyeing, testing and high polymers. Each student must select most of these courses as well as courses in other engineering schools on the campus. One of the prerequisites for the Master's degree is a thesis, and much very fine research work has been accomplished by graduate students in the course of their thesis preparations.

The Textile School has also conducted numerous contract research projects for both government agencies and industry and much specialized equipment is available for this type of investigation.

The faculty of the school represents a wide variety of experience and interests and is capable of handling investigations involving almost any facet of the textile industry.

New dyes and synthetic fibers are rapidly increasing the importance of chemistry in textile study. Here seniors measure dye solutions in the school's Dyeing Laboratory.



IDEAS INTO FABRICS

A Diversified and Productive Research Program Benefits Students, Industry, National Defense

by J. L. TAYLOR, Acting Director;
W. M. POSTMAN, Assistant Professor;
ARTHUR HERRON, Research Assistant;
School of Textile Engineering

Dr. Taylor and the Instron testing device, which measures the strength of yarns or fibers and automatically plots the data.

THE TEXTILE INDUSTRY—one of the oldest and best known industries in the world—was born of man's inventiveness out of his struggle for survival. Some 10,000 years ago, man realized that he could protect himself from beasts by building stockades from poles and intertwining vines through them for strength. Until he learned to use softer fibers such as wool and flax, man also made his litters and beds by a similar interlacing of vines.

During the Pastoral Age (about 3,000 B.C.) it became socially proper to wear clothing. And in the heyday of the Roman Empire, the art of spinning became highly developed.

The invention of the cotton gin, the spinning gin, the power loom and many related machines during the Industrial Revolution transformed the early home manufacturing endeavors, based on individual skill, into one of mechanized factories in centers of heavy population. But it was the early days of the 20th Century before planned research to improve the quality and utility of textiles became of industrial significance.

As was the case in many other industries, deficiencies recognized during the First World War and the improvements accomplished as a result of research in the years between the two world wars, speeded up the textile industry's acceptance of the possibilities of research.

In textiles, as in most industries, research is now a tool for industrial survival. With our growing standards of living, increasing demands are being made by the consumer for products to make life more pleasant or more endurable. Manufacturers now know that research is essential if consumer demands and competition are to be met.

What Textile Research Means

Today, products of textile research are a part of the daily life of all of us.

Example One: The phenomenal growth of the synthetic fiber industry is a result of planned research to utilize specific fiber characteristics in meeting predetermined end use requirements as well as to provide a fiber with the properties most suited to these product demands.

Example Two: Chemical treatments to overcome characteristic fiber or fabric deficiencies or to impart new or improved characteristics have been developed as a result of increased knowledge of textile technology.

Example Three: Improved methods of manufacturing and processing have been similarly engineered as a result of research activities in many different laboratories both in the textile and related industries. These efforts have helped to provide the man on the street with apparel (and other textiles) of superior wearing quality, improved appearance, uniformity, and possessed of certain attributes designed to meet the requirements of the consumer. Water repellency, wrinkle resistance, flame resistance, shrink resistance, and wash-fastness are among these consumer requirements.

An Undecided Industry

Although ours is a growing economy and the American people accept advancements with enthusiasm there are indications that the role of textile research has been greatly underrated. In an age of nuclear energy, rockets, and talked-about trips to the moon, the public may be overlooking even its own proprietary interests in the recognition of research accomplishments of one of the oldest and most essential industries.

Since Georgia Tech is located in a state where textiles is the biggest industry, interest here in research in this field seems perfectly natural.

The A. French Textile School, from its earliest days, has always tried to aid the textile industry by helping individuals or companies solve local or general problems. It has served the industry through both applied research projects on

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industrial contracts and the conduct of fundamental research programs by graduate students.

The preparation of a properly planned and executed thesis is one of the basic requirements of the textile graduate program at Georgia Tech. It is in the fulfillment of this most important aspect of graduate study that the fundamental research program is carried out. The thesis work gives the student an opportunity to apply the knowledge he has gained to the solution of problems in the textile fields.

The scope of thesis work at Tech is very broad and includes problems in each of the textile industry's major fields —yarn manufacturing, weaving, knitting, chemistry, and dyeing and testing.

Thesis problems are usually selected by the student from topics suggested to him by individual staff members. However, a student may work on a problem of his choice if, in the opinion of the faculty, it is a worthwhile one.

The first step toward the solution of a thesis problem usually consists of a thorough literature survey, in order to determine what work, if any, has been done in the selected field. Then, on the basis of the survey findings, the actual experimental work is laid out by the student in consultation with his advisor.

Students doing research work at Tech have available to them the services and equipment of other campus departments including the Engineering Experiment Station and its Electronic Computer Center as well as those of his own school of specialization.

A considerable amount of financial assistance is available—in the form of assistantships, instructorships, and fellowships—to deserving students to enable them to pursue graduate work in textiles at Tech.

Graduate research in the textile school is used primarily as a teaching tool. The student learns how to approach and solve new problems. He is given an insight into the problems faced by those who devote themselves primarily to research. And, equally important, he is forced to put down his thoughts and experimental results in clear, concise English. And, as in the past, this work will continue to answer many of the fundamental problems faced by the textile industry.

Applied and basic research work on a project basis is offered to government and industry by Georgia Tech through its Engineering Experiment Station. Full-time research personnel as well as research associates from the Georgia Tech teaching faculty are available to carry out these research projects. Georgia Tech's research facilities include modern testing equipment for both physical and chemical testing, a variety of manufacturing equipment, and some pilot-plant-scale dyeing and finishing equipment.

A Variety of Research

In recent years, Georgia Tech's research has included a variety of projects in the textile field:

Project One: a completed extensive project investigating the effects of yarn, denier, weave, fiber origin (Nylon, Orlon, or Dacron) on the air permeability of parachute cloths—a high velocity air permeability apparatus was built specifically for these studies.

Project Two: an extensive literature survey for the U. S. Army in an investigation to ascertain data, parameters and observations that might be useful in fabricating parachutes for illuminating shells for various caliber guns.

Project Three: an extensive program completed a few years ago involving the chemical treatment and fiber processing of flax for yarn manufacture. A similar program, also completed, involved chemical treatment, fiber processing and analysis of tensile strength and other properties of yarn and fabric made from ramie fiber.

Project Four: another completed project involved the study of the effect of twist on the properties of synthetic filament yarns. This study included measurement of the effect of twist on the apparent denier, yarn diameter, dry breaking strength and elongation, and energy absorption on elastic recovery.

Students measure turns per inch of yarn on a Suter twist counter, another of the special instruments available for textile research in the Physical Testing Laboratory.

Project Five: still another completed project for an industrial contractor required an investigation into the effects of different finishing agents on nylon staple fiber in processing trials on cotton equipment (a related project is presently being conducted in which processing capabilities of chemically softened staple ramie fiber are being investigated. Processing equipment variables are being investigated to ascertain the optimum performance attainable).

Project Six: a study accomplished under sponsorship of the U. S. Department of Agriculture involving techniques for acetylation of cotton fiber. This study required pilot-plant-scale processing and analysis of the product of chemical treatment to assess the extent of acetylation accomplished under various conditions of treatment.

Project Seven: a completed project involving an evaluation of the effect of a variety of surface active agents on the scouring after dyeing of vat dyed and naphthol dyed cotton yarns and fabrics.

Project Eight: a study on the laboratory characterization of coated tarpaulin fabrics for an industrial contractor now being conducted. This study involves the testing of the original series of coated fabrics and the same fabrics after three, six, 12, 24, and 36 month periods of exposure to outdoor weathering. Tests include breaking strength, tearing strength, flame resistance, abrasion resistance and strip adhesion strength.

Project Nine: an extensive study presently underway on the comparison of different synthetic fiber yarns and their reaction to varying periods of exposure to outdoor weathering. These studies include tests on the Instron tester to obtain a measure of the effect of weathering on both tensile and elastic properties of the yarns.

Future interests and capabilities for textile research at Georgia Tech are not necessarily limited to the endeavors listed in this summary. Facilities are available for a widely varied research program in this field—one that can be a real aid to the textile industry in its efforts to continue to serve and grow.

Edited In Retrospect

A Loss for Tech

• Dr. Joseph M. DallaValle—regents professor of chemical engineering at Georgia Tech and a frequent contributor to this magazine during the past eight years—died June 1 after a short illness.

Born in New York City, 52 years ago, Dr. DallaValle received his B.S. degree from Harvard in 1927 and his M.S. and Sc.D. there in 1928 and 1930.

After over 28 years experience with government and industry, Dr. DallaValle came to Tech as an associate professor of chemical engineering in 1948. The following year he was named a full professor and in 1955 he was honored by being named a regents professor, highest academic rank on the campus.

In 1953, he received a Fulbright grant and served for that academic year as a lecturer in chemical engineering at the University of Milan in Italy. Our regular readers will remember his impressions of an Italian University published in the April 1955 issue of this magazine.

Dr. DallaValle was an extremely prolific researcher and writer and had a long list of technical publications to his credit. But we suspect that the greatest impression that Joe DallaValle made was on the many graduate students who received the benefit of his encouragement and advice. He was a great judge of scientific talent and spent much of his spare time working with the graduate program at Georgia Tech.

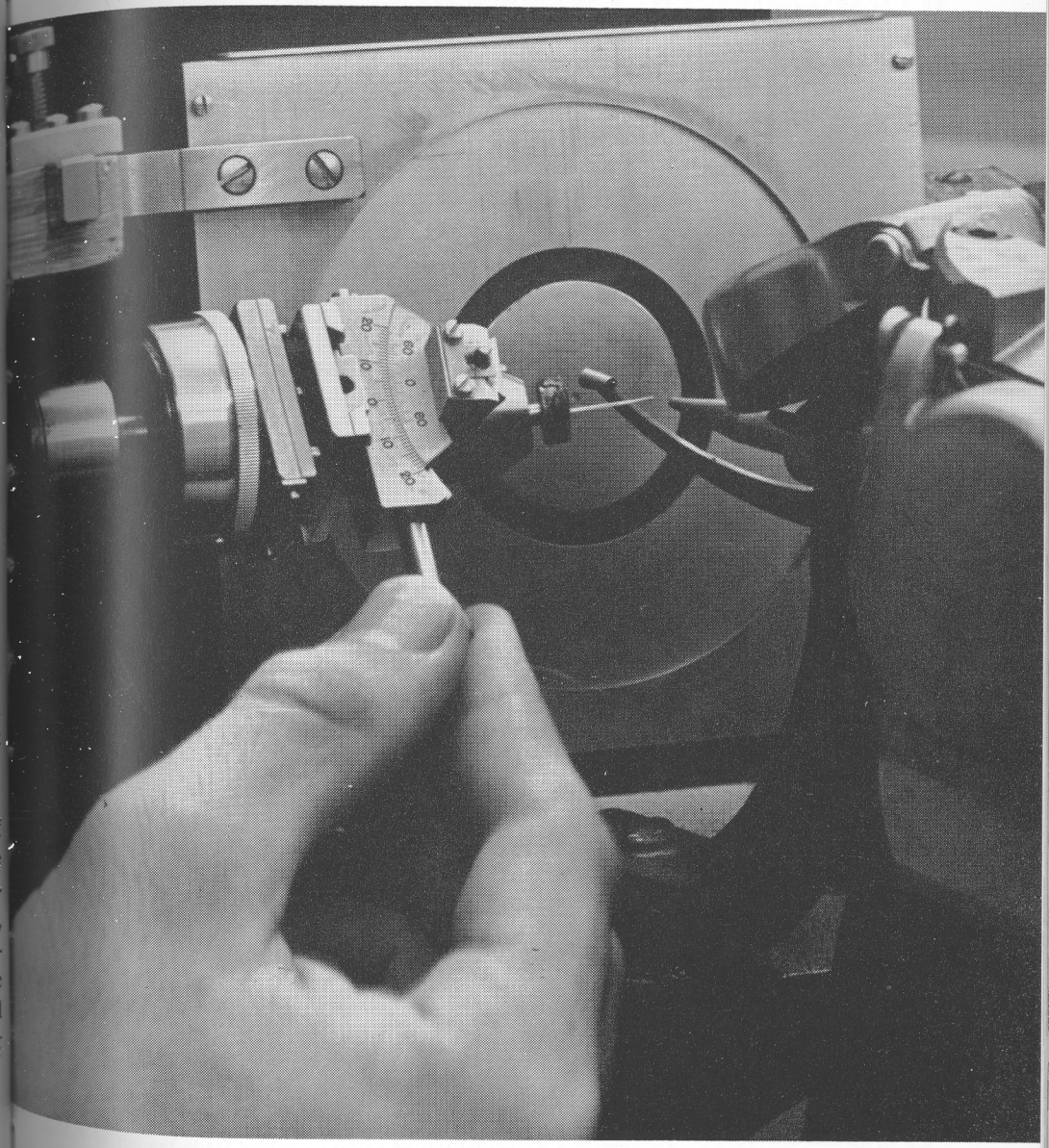
A New Schedule

• This may well be the last July issue in the history of THE RESEARCH ENGINEER. Beginning with the next issue we are inaugurating a new publishing schedule on a five-times-a-year basis. A copy should reach you in January, March, May, September and November. This new schedule is being adopted in order that we may publish the annual report of research at Georgia Tech as a special issue. We hope that you will be looking for the September issue which will be devoted to this annual report.

OCTOBER, 1958

The Research Engineer

Published by the Georgia Tech Engineering Experiment Station



A SPECIAL RESEARCH REPORT