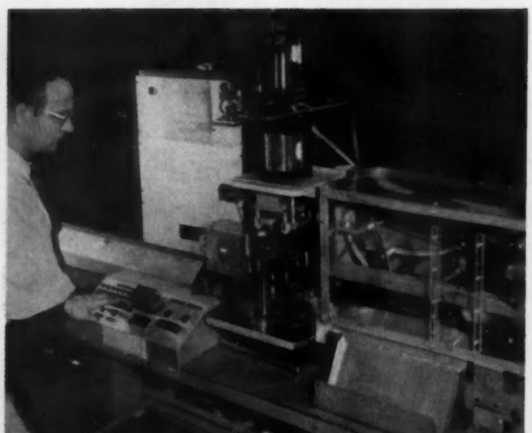
GENERAL ELECTRIC
Review
SEPTEMBER 1957

Engineering release system of punched-card computers stores and speedily retrieves data on design, manufacture, and procurement, while . . .

. . . a tape produced by programmer from dimensionless drawing signals a press to punch holes in wiring boards, and . . .



. . . square hollow tubes for assembling electronic chassis are cut to size by this machine. It's part of an over-all program of . . .

Automating for Limited and Large-Scale Production

PAGE 30

Robert M. Parke, M.S., University of Michigan (1933), joined the General Electric Research Laboratory in 1952, and now serves as manager of the *Materials Application and Evaluation Section.* He is a widely known authority on refractory metals, transformations in steel, and metal processing, and he has served as a civilian advisor to the Army, Navy, and Office of Scientific Research and Development.

"Difficult" metals aid defense

New processing techniques developed by General Electric's Robert M. Parke make casting of refractory metals easier

The word *refractory* implies "difficult." The *refractory metals* — such as tungsten and molybdenum — are very difficult to melt and cast, but their high melting points go hand in hand with their outstanding high-temperature strength. Thus these metals, previously used mostly as wire and thin sheet for electrical and electronic devices, now are needed in large pieces for modern defense equipment such as jet engines and missiles.

Robert M. Parke has helped solve many of the problems associated with casting ingots of "difficult" metals weighing several hundred pounds. He and his associates at the General Electric Research Laboratory have developed new techniques for "growing" electrodes of refractory metals, permitting continuous melting and casting in special arc furnaces. The ingots produced by these processes are extremely pure as well as large. This means improved materials not only for defense, but for products used in the home and industry.

At General Electric, such research is motivated by a belief that providing scientists with the tools, the incentives, and the freedom to seek out new knowledge is the first step toward progress for everyone.

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Review

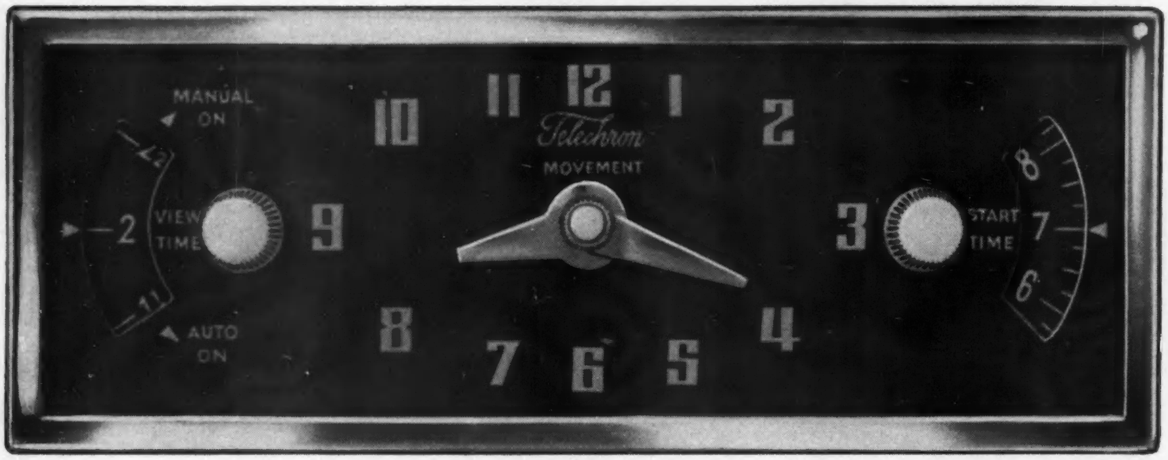
SEPTEMBER 1957 VOLUME 60 NUMBER 5

The GENERAL ELECTRIC REVIEW is issued in January, March, May, July, September, and November by the General Electric Company, Schenectady, NY, and is printed in the USA by the Maqua Company. It is distributed to scientists and engineers throughout industrial, consulting, educational, professional society, and government groups, both domestic and foreign. . . . . The GENERAL ELECTRIC REVIEW is copyrighted 1957 by the General Electric Company, and permission for reproduction in any form must be obtained in writing from the Editor. . . . The contents of the GENERAL ELECTRIC REVIEW are analyzed and indexed by the Industrial Arts Index, The Engineering Index, and Science Abstracts and are available on microfilm from University Microfilms, Ann Arbor, Mich. . . . For back copies of the REVIEW—1903 through 1954—contact P. and H. Bliss Co., Middletown, Conn. . . . Six weeks' advance notice and old address as well as new are necessary for change of address. . . . Send communications to Editor, GENERAL ELECTRIC REVIEW, Schenectady 5, NY.

COVER

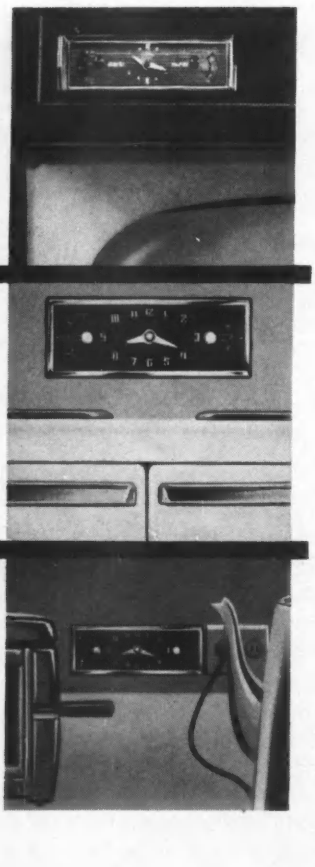
Faced with the problem of industrial preparedness in a highly complex industry, General Electric's Light Military Electronic Equipment Department, Utica, NY, instituted a program of automation based on an over-all systems concept. The photos illustrate some of the concrete steps taken to date. The story behind this bold new program is related in the article beginning on page 30.

new



LONG . . . LOW . . . LUXURY-LOOK

custom-styled, competitively priced, all-purpose timer



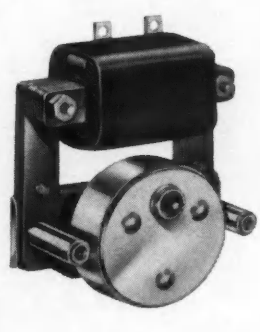
For TV sets

For Ranges

For Appliance Centers

It's here! The best looking, easiest to use appliance timer on the market. This new timer, like all Telechron timers, is made to out-value competition. It is custom-styled . . . motored for long life . . . ruggedly built for service-free operation. *And* it is low in price for volume sales. Our engineers will gladly work with your staff in the application of this or other Telechron timers to your products. Simply write, wire or phone Telechron Timers and Motors, Clock and Timer Dept., General Electric Co., 203 Homer Ave., Ashland, Mass.

Telechron timing motors are used in ranges, clock-radios, washing machines, TV sets and many other appliances. They are famous for dependability, long life and low price.



TELECHRON

MARK OF TIMING LEADERSHIP

New trends and developments in designing electrical products . . .

- First radially heat-treated magnets ever mass-produced
- G-E thermistor makes new temperature controls more sensitive

G-E Magnet Engineers turn idea into reality

The physicist at Roanwell Corp., Brooklyn, New York, had the idea – but it took a revolutionary development in magnet manufacture to make it come true.

Roanwell was working on a new receiver for military headsets sensitive enough to distinguish sounds clearly, even under combat conditions.

A new, dynamic receiver design solved the sensitivity problem. But then the weight and height of the unit had to be reduced to make it less bulky in the aviator's helmet.

Original specifications called for an assembly of several magnets which was smaller than the plug-type magnet normally used. But the Roanwell physicist's idea was to use a *single* radially heat-treated Alnico 5 magnet to reduce the size still further, and eliminate extra fabrication steps.

No one had ever mass-produced a radially heat-treated magnet like this before (Fig. 1). And no one knew if it could be done. So Magnet Engineers from General Electric were called in to try.

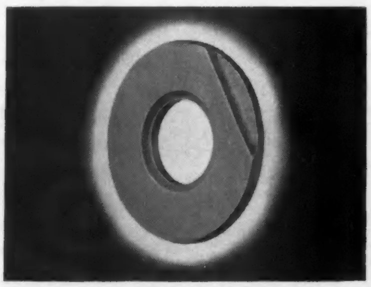


Figure 1

They solved the problem all right. But here's what they had to go through to do it:

First, they came up with special directionalizing equipment to orient the magnetic domains so the magnet could be magnetized radially.

Next, with engineers in G.E.'s unique Quality Standards Laboratory, they worked out the processing technology for mass production.

This meant starting from scratch to determine the initial heating temperature, rate of coiling, best field shape. It meant calculating axes of the directionalizing coil, computing proper aging time and temperature. And finally, it meant thorough testing and careful control of production.

The result: Roanwell is now using the first commercially produced radially heat-treated magnets (Fig. 2). The magnet produces the same flux density, but it requires less height (in fact, about half the height of a plug magnet).

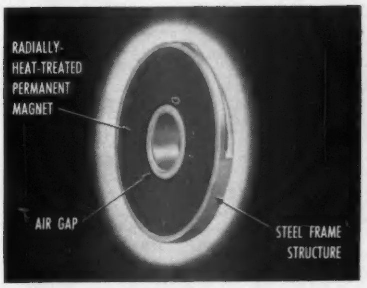


Figure 2

Because a single magnet is used, the unit is stronger, more reliable . . . and has the needed sensitivity. Equally important, the magnet can be machined accurately. This is critical because the circular air gap for the vibrating coil (see Fig. 2) is only a few thousandths wide, and magnet tolerances must be held as tightly as possible.

For Roanwell, G-E Magnet Engineers came up with this new method for mass-producing radially heat-treated magnets. For other manufacturers, they have handled jobs ranging from the design of complete magnetic circuits to development of new magnetizing and testing procedures.

Whatever the problem, G-E Magnet Engineers have the experience, skills, and the facilities behind them to solve it.

To get their expert design assistance, or your copy of the new G-E Magnet Design Manual, all you have to do is write: *Magnetic Materials Section, General Electric Company, 7802 N. Neff Blvd., Edmore, Mich.*

G-E thermistor gives new temperature control sensitivity to 0.075° F.

Furnace heat maintained at given levels, and alarms sounded when temperatures exceed specified limits – both can be controlled by a new device called the "Simplytrol."

The Simplytrol is made by Assembly Products, Inc., Chesterland, Ohio. It responds to changes as small as 0.075° F. because it uses a G-E thermistor as the sensing device.

The thermistor is one leg of a bridge in circuit with a D'Arsonval meter relay. (Fig. 3).

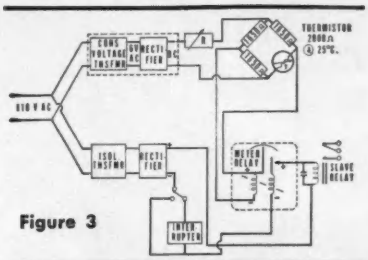


Figure 3

Because the thermistor has a large *negative* temperature coefficient of resistance, even minute changes unbalance the bridge to let the current actuate the relay.

The thermistor is more sensitive than other types of sensing elements. And in the Simplytrol, it can be wired up to 200 feet from the control without affecting accuracy.

In these and similar devices, the thermistor senses changes in ambient temperature. However, when it is heated by the current of the circuit, a whole new range of applications is opened: voltage regulators, time delays, sequence switching devices.

If you have problems in these application areas, experiment in your plant with G-E Thermistor Kits – they're only $12.50 each. To find out which is best suited to your needs, write: *Magnetic Materials Section, General Electric Company, 7802 N. Neff Blvd., Edmore, Michigan.*

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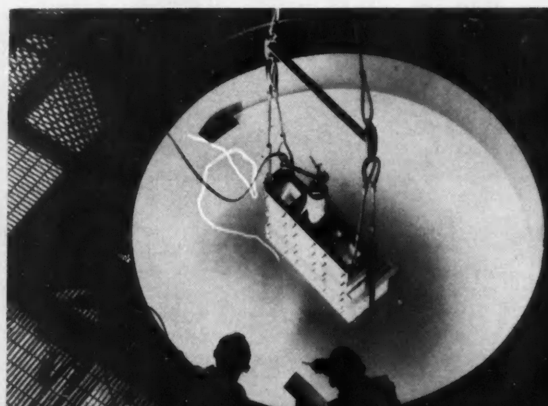
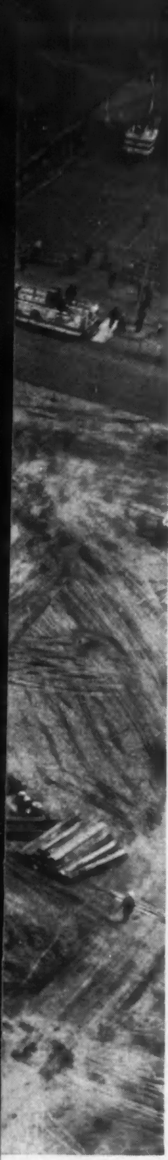
PROGRESS REPORT ON DRESDEN STATION

GENERAL ELECTRIC DUAL-CYCLE BOILING WATER REACTOR will be housed in 190-foot steel sphere on foundation already completed at Dresden site. Turbine building construction, lower left, is well under way.

DEVELOPMENTAL BOILING WATER REACTOR at General Electric Vallecitos Atomic Laboratory will furnish vital operational data to be used for Dresden Station. Turbine-generator for facility will be owned and operated by Pacific Gas and Electric Company.



REFUELING PROCEDURES AND EQUIPMENT DESIGN are studied in 54-foot-high refueling test tank in San Jose. Tank simulates reactor pressure vessel conditions, including heat and water-circulating factors.



Full-scale construction begins on world's largest all-nuclear power station

WORK ON GENERAL ELECTRIC-DESIGNED DRESDEN NUCLEAR POWER STATION MOVES AHEAD "ON SCHEDULE"

A milestone in atomic progress was passed June 12 with the start of major construction on Commonwealth Edison Company's Dresden Station. During brief ceremonies at the site one of the huge columns which will support the 190-foot sphere was swung into position and bolted into place by key officials.

Plant engineering for Dresden's dual-cycle boiling water reactor is over 55 percent complete. General Electric and the Bechtel Corporation (engineer-constructor) have let contracts to over 175 companies who are fabricating various parts of the plant.

General Electric is utilizing its development facilities at its Atomic Power Equipment Department in San Jose, California and its nearby Vallecitos Atomic Laboratory for the Dresden reactor. More than $31,000,000 has already been paid out or committed for materials and equipment.

A pioneering spirit is being demonstrated at Dresden. Commonwealth Edison and General Electric, in co-operation with the Nuclear Power Group, Inc., have displayed industrial leadership in developing a new concept of power generation which will make the peacetime atom a working reality in the Chicago area by 1960. General Electric Co., Atomic Power Equipment Dept., San Jose, California.

For more information, write for bulletin GER-1301, Progress Report on Dresden Station, General Electric Company, Section 192-11, Schenectady, New York.

MEMBERS OF THE NUCLEAR POWER GROUP, INC.—American Gas & Electric Service Corp., Commonwealth Edison Company, Pacific Gas & Electric Company, Union Electric Company of Missouri, Illinois Power Company, Kansas City Power & Light Company, Bechtel Corp., Central Illinois Light Company.

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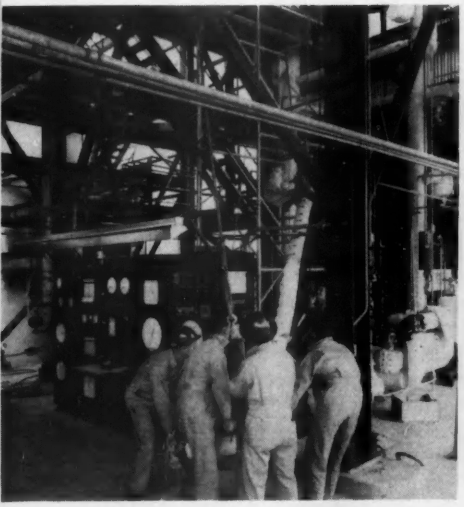

HEAT TRANSFER AND FLUID FLOW are tested in this special test loop designed for study of void distribution, steam slip, steam blanketing and heat transfer.

TWO-PHASE FLOW TEST mock-up of dual-cycle BWR steam system simulates coolant flow and steam void characteristics for this type reactor's coolant system.

CRITICAL EXPERIMENTS at Vallecitos Atomic Laboratory will be performed with Dresden core mock-up to study core configurations and fuel loadings.

Got a lamp or lighting problem?

Try General Electric's big "Supermarket of Information"

Maintenance man or corporate executive . . . home maker or business builder . . . if you have a lamp or lighting problem you'll probably find the solution in one of the more than 120 pamphlets in General Electric's lamp or lighting "Supermarket of Information".

25 Industrial Lighting Solutions, for instance, gives a full cost-of-light study for different types of plants. **Lighting Maintenance** covers the economies of replacing all your lamps at one time. **Dimming Systems** explains this exciting new commercial lighting treatment. Spot and flood lighting is covered in **G-E's Complete Line of Projector and Reflector Lamps.**

These, and more than 115 other factual booklets and pamphlets are available for the asking. Just send your request to: General Electric Co., Large Lamp Dept. GER-97, Nela Park, Cleveland 12, Ohio. Be sure to state your lamp or lighting problem—or, the subject on which you'd like to receive descriptive literature.

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Guest Editorial

ENGINEERING IS WHAT WE MAKE IT

Two events of recent months confirm and underscore the impact of science and engineering on the lives of people.

Perhaps one passed unnoticed by many: the report by government statisticians that more people are now engaged in providing the services portion of the Gross National Product than in producing the goods portion. Science and engineering have been quietly and steadily at work, multiplying man's muscle power, extending his sensory and control faculties, and turning drudgery over to machines. This resulted in a basic change in the economic pattern, with important effects upon the living and working habits of great numbers of people.

The other event made headline news: Albert Schweitzer's "Declaration of Conscience" and the controversy that followed over the testing of nuclear weapons. Society is deeply concerned with the possible impact of science and engineering on the future of the race.

Professional Spirit

These are but two examples of the vast scientific and engineering effort that have had a profound effect on people everywhere and have brought prominently to public attention the men who made these contributions. In receiving and appraising the engineer's contribution, society—to an increasing degree—will seek assurance about his qualifications, his motives, and his integrity. Society will say, as Dr. Vannevar Bush has said, "Certainly there was never a profession that more truly needed the professional spirit if the welfare of man is to be preserved."

If, as Dr. Bush suggests, engineers must exemplify the professional spirit, how do we go about it? Preceding generations of engineers have done their jobs well. Adding to their accomplishments and the reputation of the engineering profession, while at the same time making sure that both their and our contributions are properly evaluated and put to good use, should be a compelling challenge to engineers everywhere. To enhance the engineers' contribution to society—and the voluntary acclaim accorded it—I commend continuing attention of engineers young and old to three key areas: responsibilities, relationships, and qualifications.

Responsibilities

Engineering contributions are so basic and so far-reaching that leaders who have great responsibilities for the course of society need competent technical counsel and guidance. Therefore, engineers must take part in society's effort to appraise and assimilate the technological changes they generate, just as they carry their share of civic responsibility to assimilate political, economic, or philosophical change.

The British author of the book *Facing the Atomic Future* has said, "The scientist has one overwhelming responsibility to the community he serves: that is, to make available to them in a form that they can understand the facts of modern developments." Clearly, more than publication—or publicity—is needed to help the community appreciate the full implications of technological developments for society. It may involve years of missionary work plus close cooperation and mutual guidance in putting those developments to work.

Relationships

Let's make no mistake about cooperation and mutual guidance; they are completely alloyed with the other elements that make up any engineering assignment today. The special talents of people from many disciplines are needed for the engineering project itself. As the context broadens to the business enterprise, to industry, and to society itself, the contributions of other professions multiply in number and impact—including most definitely the fields of interest outside the physical sciences.

The modern idea of teamwork, as used in industry, is a most helpful guide; for the interdependence of business functions such as manufacturing, marketing, and engineering teaches this lesson well to those in industry.

From student days on, all professions would do well to foster mutual respect for the attainments of others and for their contributions to total progress. This builds a sound basis for the development and proper use of the great engineering contributions yet to come and for genuine prestige for engineering.

Qualifications

Continuing attention to the improvements of his individual qualifications is a must for every engineer who would add to the stature of his profession. Today the frontiers of engineering are moving so fast that possession, per se, of a particular degree or of a particular body of experience is a poor guarantee of continued contributions. Whole areas of established technologies, products, customer requirements, and technical objectives may become obsolete twice or even three times in one man's lifetime.

In this situation self-development is obviously a concern to all in engineering—not just to those who wish to work on designs for tomorrow. The decision as to how much and what kind of self-development are needed for one's personal objectives rests, of course, with the individual. However, if the objective is to enhance the engineering profession, neither the young man coming out of school nor the old grad of experience can expect to wrap himself in his sheepskin or his past experience and settle down for a nap.

Meeting the Objectives

Results in these three key areas impinge strongly on action by the individual. How does one address himself to this situation? Primarily, I should say, by simply doing one's present job better—with special daily concern for *my* responsibilities, *my* relationships, and *my* qualifications for the assigned task.

A summation of individual engineering jobs done well provides growth and recognition for those already in the profession; adds to the stature and reputation of engineering as a profession; and assures continuing challenge, leadership, and opportunity for the young people about to embark on engineering as a career.

Clarence H. Linder
VICE PRESIDENT—ENGINEERING SERVICES

Defense Needs, more involved as their effectiveness multiplies, demand . . .

Giant radar units are among the products growing more intricate with every advance of science. Only through the maximum teamwork of American business, small and large, can such needs be met. A small Pennsylvania plastics manufacturer and General Electric's sprawling Evendale, Ohio, turbojet-engine plant are both vital contributors to defense.

Putting National Defense on a Business Basis

By C. W. LA PIERRE

Like the private citizen, the responsible *corporate* citizen—both large and small—today re-evaluates its thinking about national defense. Forward-looking management arranges its human and material resources to best team with other businesses to tackle the ever-tougher defense problems.

This mental and physical gear shifting becomes necessary for many reasons. For one thing, the peace-minded democracies today can no longer hope for any "lead time" in which to convert their economies from predominantly civilian production to the build-up of military hardware. Nuclear weapons, high-speed bombers, and guided missiles have wiped out both time and space. Thus our nation has a dual economic goal: continue to advance our levels of living; and devote a sizable portion of our research, development, and production toward the strengthening of our defense.

Achieving this "security with solvency" is a basic problem in meeting the nation's defense plans. With defense budgets approaching $40 billion each year and other related expenditures such as foreign aid and veteran expense maintaining high levels, exploration of every possibility in securing the maximum defense for the taxpayers' dollar by government and industry becomes imperative. A businesslike approach to defense can help to accomplish these objectives (Box, page 13). General Electric is marshaling its talents and facilities to help meet the defense needs of the United States.

Free-Society Incentives Needed

Though bold risk-taking to produce great technological advances is as important in national defense as in civilian business, the incentives in defense work lag far behind others in our economy. For example, General Electric's defense-work profits fall substantially below its commercial business profits and amount to less than half of what the public, according to opinion surveys, considers a fair profit.

A free society such as in the United States depends on incentives, rather than coercion and centralized control, to achieve results. The outstanding success and productivity of civilian economy proves that free enterprise incentives produce superior results.

To gain the full values out of industry participation in defense work, the same incentives for performance should be found as elsewhere. Share owners should

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Mr. La Pierre is Executive Vice President—Electronic, Atomic, and Defense Systems Group, General Electric Company.

. . . Small Business skill and experience, often in the role of subcontractor . . .

. . . and Large Business resources, working together in a matchless combination.

have the opportunity to earn a return sufficient to warrant their investing personnel, facilities, and money in defense projects.

Much needs to be done, however, to provide returns on defense accomplishments that match the returns from commercial business. Narrowing this gap would mean an important step toward infusing into defense work the same impetus that keeps the civilian economy vigorous, growing, and able to supply good values to customers.

Insofar as possible, we should try to avoid the situation where business is rewarded for its performance of American duty through an administered-profit or nonincentive relationship. Those businesses that demonstrate their capability for more efficient operation and more courageous risk-taking should be recognized with all the directness we can bring to bear on such activities.

Keep Politics Out

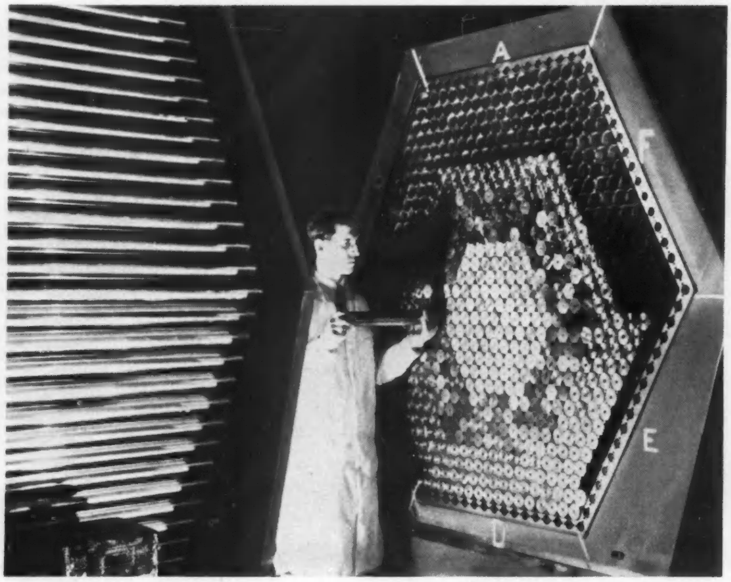
The government should avoid regarding the budget for national defense as a political or relief fund. It should simply place contracts as effectively and economically as a business would. No commercial enterprise would award contracts in so-called economically depressed areas—areas usually unable to hold industry because their costs are too high. Contracts sustaining such areas artificially simply postpone the adjustment to competitiveness that will some day have to be made.

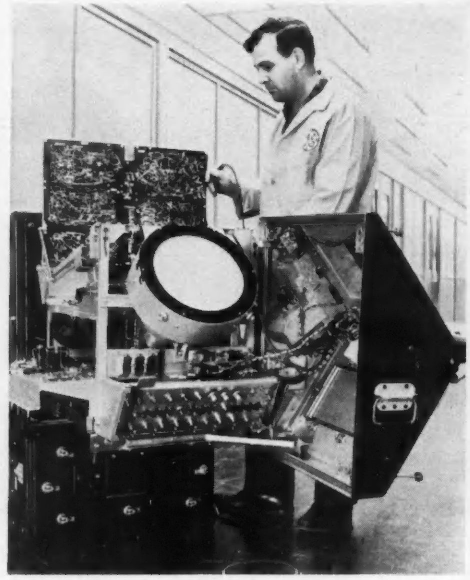
Failing companies, large or small, unable to compete for whatever reason, have not earned the right to serve the Armed Forces. Political support of plant communities can sometimes be purchased with a contract; efficient supply to the military cannot.

With present size national budgets, government procurement policies are powerful documents. Unfortunately, they are all too frequently directed toward minimizing the incentives necessary to support innovation. Principally, this means failure to understand the importance of a corporation's experience and ability in contributing toward any new product or result that the organization is capable of delivering. If important new results are to be achieved, the fundamental skills and basic facilities offered by a business must be fully appreciated by those responsible for placement of defense work.

Cost Reduction Vital

Various methods of cost reduction need further encouragement. The nation requires maximum incentives to achieve proper cost reduction in national defense activities. On large projects, continuing cost-reduction activities reveal dramatic results in terms of better defense





COMPLEXITY keynotes today's defense requirements in atomic products (left) and electric components. Scores of subcontractors are combining their talents with 32,000 General Electric employees in plutonium, radar, missile, and nuclear propulsion work.

for the taxpayer's dollar. For example, General Electric's J79 jet engine delivers twice the thrust of the earlier J47 yet weighs less, utilizes a minimum amount of critical materials, and saves $50,000 per engine by using alloys in place of expensive titanium.

The only trouble with certain incentive government contracts was that they offered too little incentive. Cost reductions brought the producers only a fraction of the first year's savings and none of the benefits during subsequent years. Larger incentive offerings would have cut red tape, saved time, and stimulated competitive performance in defense work. This application of the principles of our economic system, when reflected in more liberal contracts, will bring greater values for our defense dollars. As we shift the atmosphere of defense work to a more businesslike plane, we will see a more rapid progress in the economic procurement of defense equipment.

Small Business Essential

Both large and small businesses are necessary to the performance demanded of American industry today. The technical problems grow to be more unwieldy with every advance of science. Only by utilizing the maximum effectiveness of American industry can we solve the present scientific, engineering, and manufacturing problems. The challenge can be met by developing a highly productive teamwork between small and large businesses, with each enterprise contributing the products or services which it is best able to contribute.

Larger companies perform an essential service by taking on vast and complicated problems too broad for smaller companies to handle, then breaking them into segments manageable by smaller or more specialized companies. This is a healthy economic process because it helps insure economic mobilization of all the nation's productive skills and resources in the national defense. It opens opportunities for thousands of smaller companies to participate in projects that would otherwise be too large and complex for their capacities. It spreads defense know-how among many companies, broadening the country's defense potential.

Smaller Firms: Suppliers

Some people who charge that defense business is being concentrated in companies with outstanding research and production facilities have twisted the facts arising from the subcontracting practice to arouse prejudice against these companies or to discredit their achievements. Usually they do this by citing prime contract figures and ignoring the huge portions of these contracts carried out by smaller firms serving as suppliers. General Electric, as an example, has accepted the over-all responsibility for the development and production of jet engines. But in carrying out its current production of the J79 engine, the Company provides business for suppliers who handle more than half of the actual production.

General Electric makes it possible for suppliers to contribute far more than merely routine production. Through its value-analysis seminars, the Company regularly outlines its problems and goals to interested suppliers and invites their ideas; many suppliers have helped improve products or processes while opening the way to new businesses for themselves. This creative teamwork enables the nation's defense effort to benefit from the independence, ingenuity, flexibility, and specialized skills and facilities of thousands of small or highly specialized businesses (Box, page 14).

Large Business Important Too

Fortunately in America the rising levels of living and increasing demands of customers allow many companies to develop a breadth of scope and a depth of technical manpower capable of encompassing the most complex problems of defense. The industrial teamwork embracing many types and sizes of businesses and presenting so many opportunities for small businesses depends heavily on responsible large-scale enterprises to provide the over-all direction and coordination that makes possible the participation of many small and highly specialized enterprises—a fact that should not be obscured. Some of the complex and difficult projects that large-scale enterprises have accepted over-all

CONCLUDED ON PAGE 14

GENERAL ELECTRIC AND NATIONAL DEFENSE

At General Electric we have built our defense orientation around these concepts . . .

- Missiles, jet aircraft, and nuclear weapons are too complex for any but the full breadth and depth of American industrial skill.
- While large organizations possess the broad technical skills and resources to provide general coordination of difficult projects, they simultaneously create challenging opportunities for the nation's array of smaller and middle-size businesses.
- Government and business should share in the responsibility to minimize the costs of defense as living levels continue to advance. Both human and material resources should be conserved.
- By putting the tested American profit incentive system to work in the cause of national defense, we can realize the greatest tax savings and technical advances.
- Business should accept defense as a continuing duty, depending as little as possible on the emergency conversion of inapplicable facilities. Crash programs are costly and wasteful.

To help meet the nation's defense objectives, General Electric has remolded its basic organization structure so that a major, integrated part of the Company is specifically and continuously devoted to meeting technically difficult defense needs.

Another aspect of our awareness of defense work as an integral and continuing part of our effort toward the national welfare shows itself in the high proportion of total output that the Company devotes to defense equipment. High in each of the postwar years, this proportion currently reaches about 20 percent. And an even higher percentage of the Company's technical manpower is assigned to defense projects. General Electric makes these investments even though the utilization of facilities and manpower in defense work yields an unsatisfactory return compared with similar investments in production for civilian markets. These investments are made in the expectation that the American people ultimately will want those who carry forward such programs to be equitably paid for their services.

Concentration

Much of our defense activity is concentrated in the Company's Electronic, Atomic and Defense Systems Group. The operations of three of its divisions concerned primarily with defense work illustrate the results of this kind of organization concentration. The largest in terms of employment (23,000) has produced more than 31,000 engines for jet aircraft. Their current product, the J79, has the highest power-to-weight ratio yet available.

Another highly concentrated defense activity takes place in our 12,000-employee Atomic Products Division, which makes plutonium and is developing nuclear propulsion for aircraft, submarines, and a Navy destroyer. The Defense Electronics Division makes components and systems for missile programs; for air, ground, and marine radar; for undersea detection devices; and for airborne radar jammers, armament, and communications equipment.

Company-Wide Defense Team

In addition to these three divisions—primarily concerned with defense work—the majority of our other Company branches aid in defense work. Some examples of their contributions are: ship propulsion turbines and gear equipment, aircraft instruments of many kinds, special metals and alloys, heat-resistant rubber and chemicals, x-ray equipment, electronic communications systems, motors for pumping radioactive materials, and other special motors and generators.

Further, the Company's unique Services organization backs the work of these branches by providing specialized knowledge and expert assistance in the broad business functions of research, engineering, manufacturing, marketing, accounting and finance, law, management consultation, and the development of sound relations with all who contribute to and share in the Company's success.

Thus defense work at General Electric benefits not only from the facilities applied specifically to defense problems but also from the full range of the Company's manpower experience and material resources.

Investment in Defense

Our Company has made a manifold investment in defense, including both trained manpower and material resources. Among the broad resources for defense are outstanding scientists, engineers and technicians, responsible management, private funds invested in facilities, research and development, leadership, world-wide application and service engineering, and a broad stand-by capacity.

The challenge to stay ahead of potential aggressors means leadership in quality of men and ideas as well as equipment. We invest the talents of many of our most highly trained, most creative people in assignments to defense. Company conducted educational programs help these talented people to further develop their abilities and keep up with new defense technologies.

We extend to our decentralized defense activities the same professional management skills that have proved successful in the conduct of our commercial business. The managers of defense businesses are accountable for the successful conduct of their operations in terms of effective planning, organizing, integrating, and measuring the performance of their organizational components.

Private funds play a vital role in the conduct of a large portion of our defense activities—primarily in research and development facilities. For example, the Aircraft Gas Turbine Division has privately owned facilities with a replacement value of more than $135 million. The government owns less than 20 percent of the 7-million square feet of floor space utilized there.

And defense work at General Electric benefits from research and development in our Research Laboratory, in our laboratories for engineering and manufacturing advancement, plus the 39 other scientific laboratories associated with product departments.

Wherever the need for expert assistance in the application, maintenance, and servicing of complex defense equipment occurs in the nation's far-flung defense perimeter, we try to meet it with our world-wide organization of trained people backed by well-equipped service facilities. The Company's technical representatives help train Armed Forces personnel in the use of complicated weapons systems.

The great reservoir of trained manpower and broad production facilities built up by the Company forms an enormous stand-by capacity, maintained without cost to the taxpayers. As with other large companies whose products meet broad customer favor, General Electric's manpower and facilities represent a potential force of great magnitude that doesn't have to be revitalized or taken out of mothballs. It stands ready to serve at all times.

HOW BIG JOBS HELP SUPPLIERS GROW

The firm of S. H. A. Young of Swarthmore, Pa., provides a good example of how a supplier has helped General Electric solve a problem and, in the process, developed a business for himself. Problem: packaging of electronic devices for flights to bases around the world. Our Light Military Electronic Equipment Department sought a new container that would be stronger, smaller, lighter, more resistant to climatic conditions than former containers. Solution: a plastic container giving proper protection, discovered by a General Electric engineer—Richard Thomas—working in cooperation with Young. The new container can be mass produced at low cost and is reusable. Young's small firm, formerly in a 20 x 40-foot laboratory, has invested in a factory to produce plastic products —not only for General Electric but also for other companies engaged in defense. Young, in turn, has licensed other manufacturers.

General Electric developed opportunities that were responsible for payroll growth at the firm of Countney and Malcom Kratz, Covington, Ky. Orders for jet-engine parts have enabled the firm to increase employment 25 percent to a present payroll of 25.

The Elano Corporation of Xenia, Ohio, contributes to fuel systems for jet engines. Elano, 90 percent of whose production goes to General Electric, is one of more than 100 businesses supplying parts for the J79 jet engine.

Excelco Developments, Inc., Silver Creek, NY, manufactures earth satellite engine parts. This company's business with General Electric has grown from a $216 order in 1948 to sales that have passed the million-dollar mark.

NATIONWIDE TEAM of subcontractors plus General Electric know-how combine to produce the J79 engine, powering the new B58 supersonic bomber.

responsibility for are: giant radar units that form links in the nation's air-attack warning system, nuclear power plants for aircraft and naval vessels, guided-missile systems, and jet aircraft.

Spread the Word

Engineers and scientists, many of whom are associated directly or indirectly with the defense work of the United States, can do a great service to their country by helping broaden public understanding of the facts about national defense. In your professional circles, as well as your civic and social activities, you can help a great many individual Americans understand . . .

• *Why a more businesslike approach to defense is in the nation's best interest.* Efforts by industry and military agencies to infuse into defense work the same incentives that make the civilian economy so productive in good values may be misinterpreted if the public is either uninformed or incorrectly informed about the objectives. You can help more people recognize that a sound profit system can lead to greater values in defense procurement in the same manner that it brings better values to civilian customers.

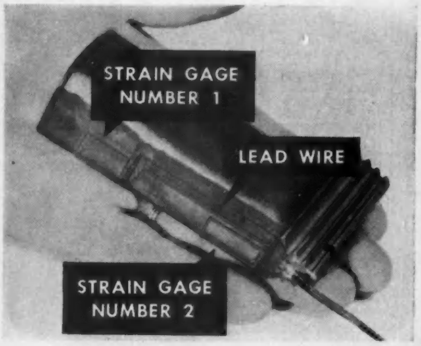
• *Why politics must be kept out of defense.* Pressures for using defense funds for purposes other than the most economical purchase of defense goods begin with groups of people who put a narrow or local interest ahead of the common good. When this happens the results are high-cost relief and inefficient procurement. You as thoughtful citizens can do much to help oppose such short-sighted procedures.

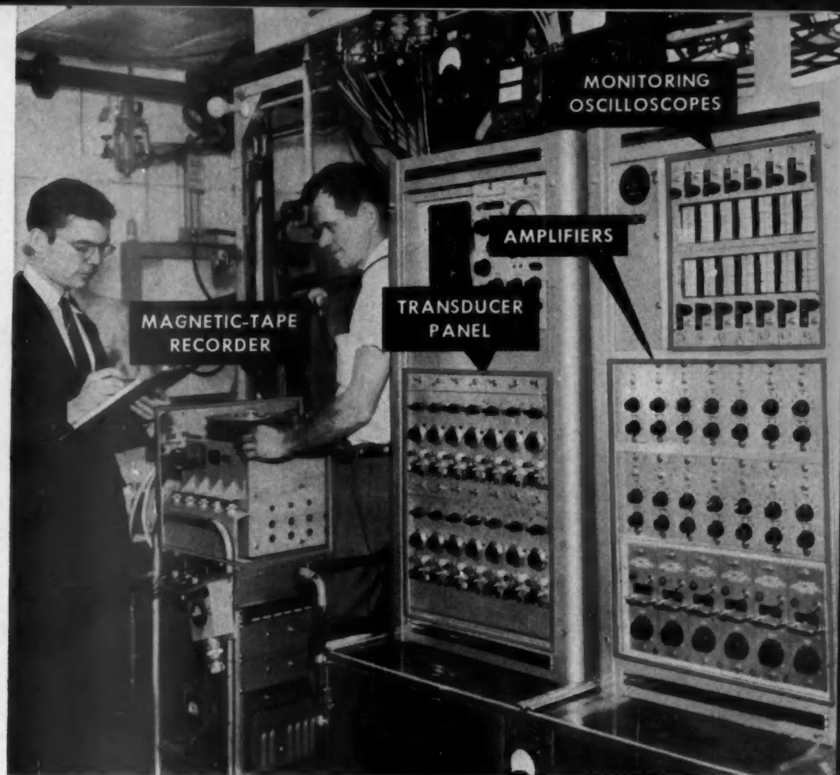
• *Why present-day defense would be impossible without large-scale enterprises.* Efforts are constantly being made to use the defense contracts awarded to large companies as the means of promoting public hostility to these companies. You can help more Americans become aware of the essential role that large enterprises play in taking on the over-all responsibility for big projects and developing a teamwork benefiting thousands of small firms.

• *Why the nation must accelerate development of technical manpower.* In their work for national defense, companies across the board tackle new problems on the frontiers of human knowledge. This will continue to call for enormous numbers of talented technical people. Yet many promising young people fail to prepare in high school for the requirements of college work in science and engineering. You as an informed citizen can help by seeing that promising young people with strong scientific bents secure a good grounding in mathematics and other courses.

We can all help to advance the public appreciation for and understanding of a more businesslike approach to our nation's defense—one that takes advantage of our competitive system's best features while excluding the possibility of political considerations as factors in production relationships. The accelerating contributions made both by large and small businesses will make the nation further aware of its responsibilities in providing adequate technical manpower.

More clearly than ever in our history, this nation's defense calls for steady, ever-improving teamwork between the businesses that must build the tools we need. Whether a small, handicraft business or a sprawling industrial assembly line, forward-looking business today approaches defense work in a businesslike manner to assure both sound economic performance and delivery of full value for the taxpayer's dollar. Ω





Vital to jet-engine advancement, the highly sensitive strain gage (above) tackles the task of measuring vibratory stresses of turbine and compressor blades during engine operation. Magnetic-tape recorder aids in stress evaluation. Author stands at left.

Producing Better Jet Engines Experimentally

By B. R. ANDERSON

Experimental stress analysis is a relatively new science. Yet it contributes indispensably to the development of tomorrow's turbojet engine. For jet-engine parts are of such complex mechanical design that the engineer cannot merely run off a few calculations on the slide rule to obtain stresses.

Instead, he must apply *experimental* stress analysis—the science that solves such problems *experimentally* rather than *theoretically*. Actually, the two methods do not compete with each other, but work hand in hand to give the mechanical design engineer a better understanding to the solution of his problems.

Other reasons also dictate the need for the experimental approach. When working with an unknown magnitude, location, or direction of applied loads, the engineer must determine stresses by direct measurement. Also, a theoretical stress analysis requires a certain number of initial assumptions that might result in inaccurate conclusions. And in actual practice, the theoretical stress analyst may not have the detailed knowledge nor the time to perform the complete analysis.

Thus experimental stress analysis plays a major role in the design and development of such new jet-engine components as turbine wheels and compressor and turbine blades to operate at speeds up to 26,000 rpm at ever-increasing temperature and stresses.

Literally hundreds of methods and tools—wire-resistance strain gages, brittle lacquer, photoelasticity, x-ray analyses, inductance and capacitance gages to name a few—help the experimental stress analyst perform stress measurements. Of these, the combined versatility of the first three tools makes them indispensable to the stress analyst.

In this group the wire-resistance strain gage is probably the most widely used because it's small, lightweight, highly accurate, simple, and adaptable to the solution of many problems. The gage consists of an extremely fine filament of high-resistance wire cemented to the structure to be tested but electrically insulated from it. When load is applied, the resulting surface strain induced is transmitted to the filament wire, stretching or compressing it. This change in length is measured by detecting the change in electrical resistance of the filament for an accurate measurement of strain. In a J47 turbojet turbine bucket, two strain gages—one at the tip and one at the root of the bucket—are used (photo, left).

Lacquer and Photoelasticity Tests

Another stress-measurement tool is brittle lacquer. It is applied in thin coats to the surface of the structure to be tested. When the structure is loaded, the resulting tension strains will produce cracks in the coating upon reaching the threshold sensitivity. This tool helps the experimental stress analyst to locate areas of maximum stress and the direction of the principal stresses.

If used under carefully controlled atmospheric conditions, the coating can be calibrated and actual magnitudes of

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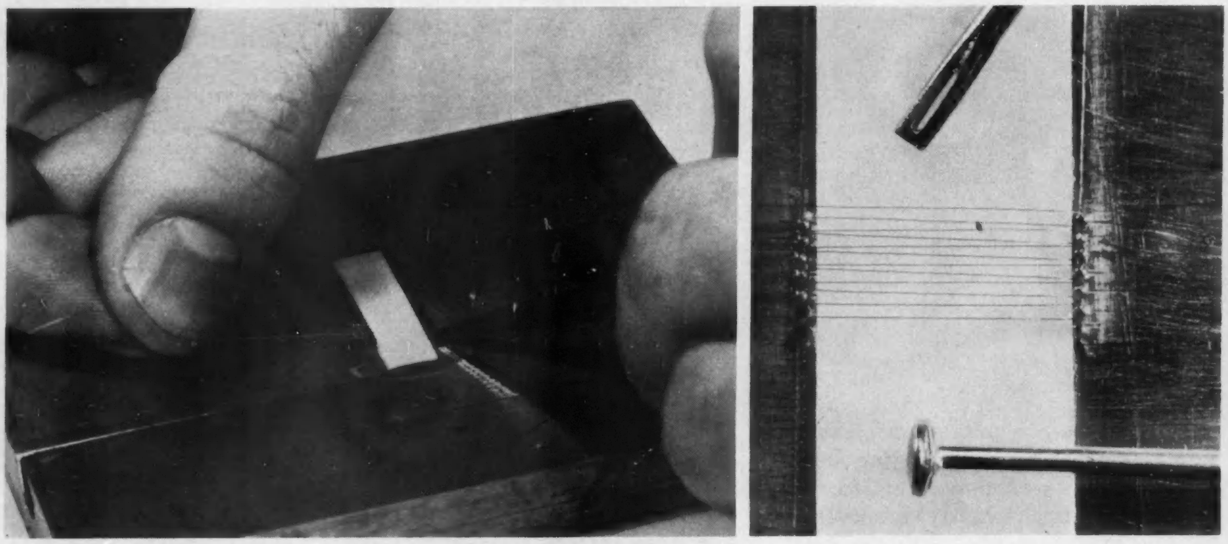
Mr. Anderson—Engineer, Instrumentation, Testing Operation, Flight Propulsion Laboratory Department, Evendale—came with General Electric on the Test Course in 1948. His past experience includes experimental stress analysis work in the Materials Laboratory, Evendale.



TINY STRAIN-GAGE GRID is formed by winding strain-sensitive wire around mounted pins—a technique requiring a great deal of manual dexterity and patience. The grid magnification (right) graphically compares the size with relation to a needle and pin.

strain determined. This method is especially significant because the entire surface of the structure can be surveyed rather than finite locations. Brittle lacquer can be applied with equal ease for measurements on rotating or stationary operating components.

Recent developments to overcome the limitation of brittle lacquer have produced a porcelain-enamel coating. It can be used at temperatures up to 700 F in the presence of oil, steam, or other adverse conditions.

Photoelasticity makes model testing valuable in three-dimensional stress studies. In this process, a precise scale model of the structure can be formed from suitable photoelastic material. After placing the model in a field of polarized light, an operator applies load to it. The resulting stresses will produce a series of brilliantly colored bands which, when interpreted, give a quantitative as well as a qualitative analysis of the stress distribution. This method adapts particularly well to the study of highly irregular and complex shapes, such as the dovetail sections of turbine blades.

Blade Vibration Studies

The Aircraft Gas Turbine Division of General Electric finds strain-gage measurements vitally important in vibration studies of compressor and turbine blades. Formerly, these measurements aided in analyzing the failure of components already in service. This was done by making actual vibratory stress measurements on the blade by the use of strain gages, slip-ring assemblies, and data-recording equipment, with the engine operating in the test cell.

Now, however, such data must be obtained on prototype engines and compressors during initial testing to insure operation within safe stress limits. These stresses must actually be measured. And the theoretical stress analyst cannot calculate the vibratory stress because both the wide variety of vibration-producing stimuli and the damping constants are unknown. Also, operating conditions in the test cell—far more severe than in service operations—require direct measurements to establish whether any partial damage has reduced the life of the blading to a potentially dangerous level.

Consequently, the vibratory stresses in the blading of each compressor and turbine stage must be continually monitored on oscilloscopes during actual test. Monitoring safeguards against operating the unit at a condition that produces high-vibratory stresses and results in a fatigue failure of a blade. You can understand the tremendous task in measuring these stresses for some engines contain more than 5000 blades: the vibratory stresses in each blade must be measured and analyzed for all frequencies and vibration nodes during actual engine operation.

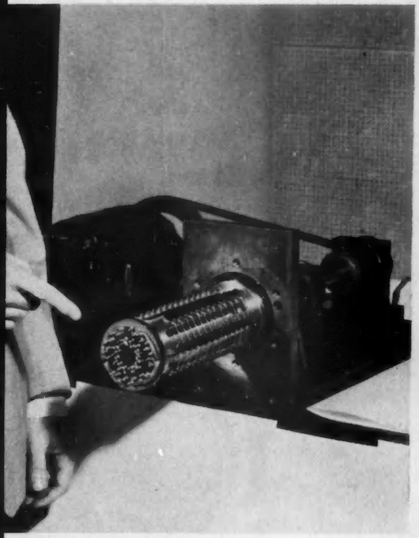
Several improved and modified techniques met these new needs . . .

- The number of gages and lead-in wires that could be attached to the blades and wheels was increased anywhere from 50 to 200. And they were designed to operate under centrifugal forces 30,000 times as great as gravity and at temperatures up to 1500 F.
- A flexible multichannel monitoring and magnetic-tape data-recording system was developed to simultaneously observe and record data from direct current to 30,000 cps.
- Slip-ring assemblies and associated circuitry were improved to simultaneously transmit more signals off the rotor with greater accuracy.
- An efficient multichannel data-reduction system was developed to analyze the tremendous number of recordings made in a single test.
- Laboratory bench testing of the vibratory characteristics of each blade was expanded to allow more detailed study on more blades.

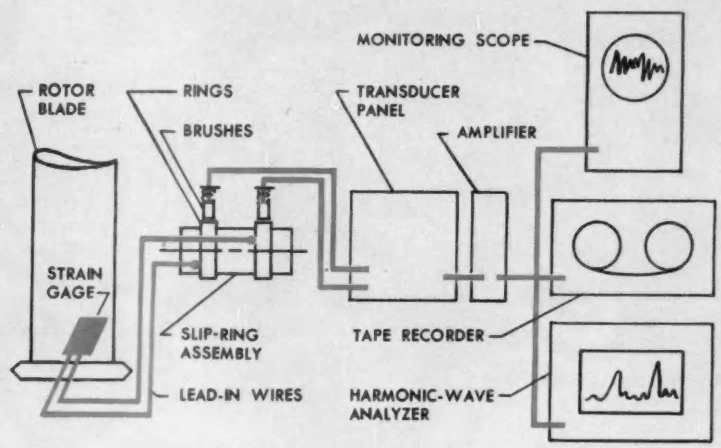
High-Temperature Strain Gages

Measuring the stresses in parts operating at temperatures between 450 and 1500 F presented a serious problem because commercial strain gages were not available. The solution: Evaluate strain-sensitive alloys and ceramic cements that could operate at 1500 F under terrific centrifugal forces and high gas pressures. In addition, techniques had to be developed for hand winding and transferring the strain-gage grid to the blade. A gage to meet these specifications was perfected about three years ago.

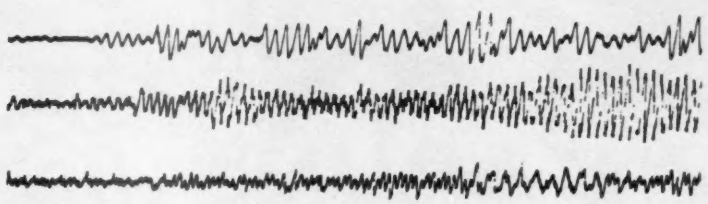
This gage is constructed by hand-winding strain-sensitive wire, one third the diameter of a human hair, around pins mounted on a brass winding fixture



SLIP-RING ASSEMBLY is vital component in circuitry that records blade vibrations.



RECORDING INSTRUMENTS schematically arranged with strain gage play important function in analyzing turbine-bucket vibrations as recorded in traces below.



VIBRATION PATTERNS of blades show low stresses of normal, unstalled operation (left) and the high stresses that occur during a stalled condition. Vibrations were traced of first- and fifth-stage rotor blades and fifth-stage stator vane (top to bottom).

(photos). When formed, the grid is removed from the fixture, placed between two hardened polished steel blocks, and flattened to approximately one half its original diameter. This operation permanently sets the grid so that it can be removed to the test structure. In this manner the grid can be cemented in place easily and accurately—thin coatings of cement insure good adhesion with negligible disturbance to critical airfoil surfaces. This job requires manual dexterity and patience. In fact, a technician receives several months training before he develops the ability to satisfactorily apply these high-temperature strain gages.

Since perfecting this technique, hundreds of high-temperature strain gages have been constructed and applied to turbine and compressor blades. The data obtained from these gages have been of great value in evaluating turbine-bucket vibration; in one engine-development program alone, about $2 million and several months time were saved.

Besides structural safety factors, many aerodynamic characteristics of compressors can be obtained by analyzing blade vibrations. For example, in the aerodynamics of airfoils, the performance might be expected to improve after adjusting the flow angle of attack to produce minimum vibration. This theory was tried during full-scale compressor operation, and the over-all flow and efficiency actually did improve at the condition of minimum vibration activity.

Compressor-flow breakdowns such as stall, surge, and rotating stall can also be detected and identified by studying blade vibration patterns (illustration, lower).

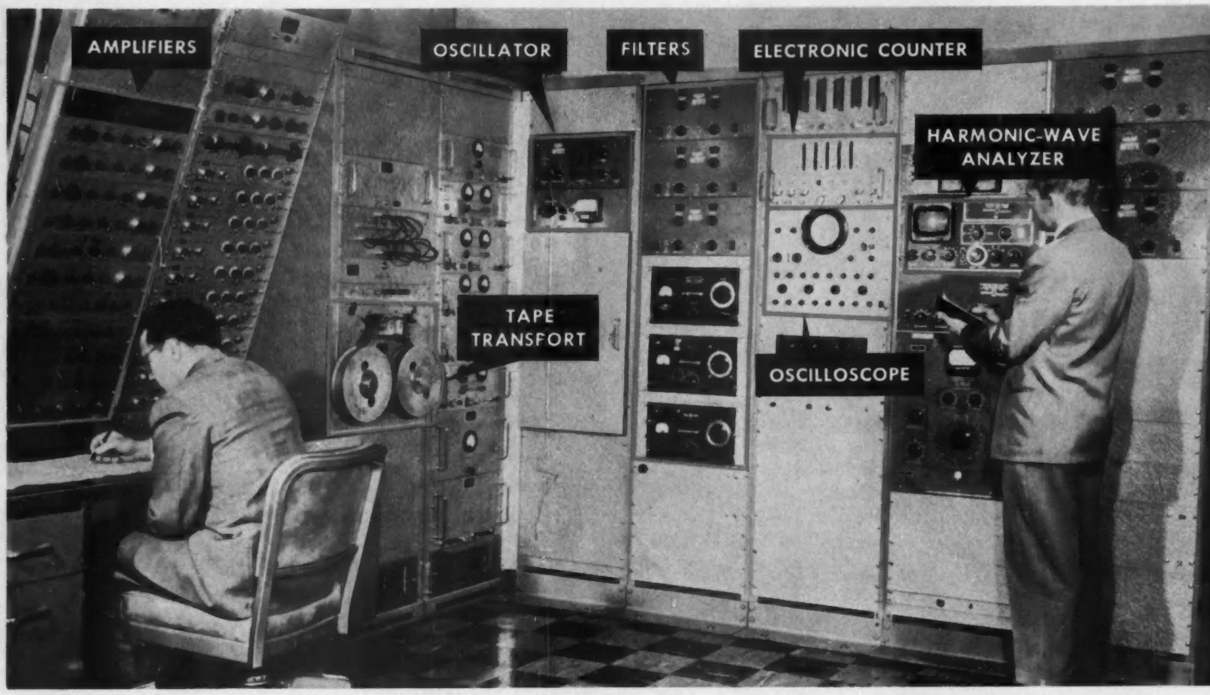
Monitoring and Recording Stress Data

The instruments used to monitor and record blade vibration play a primary part. Because of the tremendous number of blades in an engine, the instruments must contain a high number of channels yet be flexible in design, compact, and reliable in operation. The major components found in the system (illustration, top) comprise a slip-ring assembly; transducer panel; amplifier; monitoring oscilloscopes; magnetic-tape recorder; and harmonic-wave analyzer.

The slip ring transfers the signals off the rotor by means of silver-graphite brushes sliding on coin-silver rings. They must operate at speeds from 0 to 26,000 rpm, and one particular design has operated as long as 80 hours without maintenance (photo). Because slip-ring and brush materials are not perfect, special circuitry cancels the effects of variable brush-to-ring contact resistance caused by runout or brush and ring wear. Present assemblies have 13 or 26 rings that can simultaneously transfer 11 or 24 gage or thermocouple signals respectively. To meet the ever-increasing demand for more readings, improved slip-ring assemblies with 50 to 100 rings are being designed and tested in laboratory and field operations.

The gage is connected to the instruments through a transducer input panel. The transducer panel plus monitoring oscilloscopes, amplifiers, and a tape recorder (photo, page 15) accepts resistance-type or self-generating transducers. The panel also provides output jacks for feeding the signals to the amplifier. The amplifiers must raise the signal level from a few millivolts to one volt—the amount required by the magnetic tape recorder.

The amplifier output feeds three sections of the system: monitoring oscilloscopes, magnetic-tape recorder, and harmonic-wave analyzer. Primarily these



INSTANT PLAYBACK of data recorded on magnetic tape simplifies analysis of vibratory stresses, offering a tremendous advantage in jet-engine and missile testing. Skilled technicians utilizing a complex group of instruments interpret the data.

scopes provide a continuous visual picture of the blade vibration waveform during operation.

The scopes—assembled in groups of 14, one for each recorder channel—conveniently and efficiently record the 14 signals. Five 14-channel sections can be combined to form a 70-channel system.

Pen recorders, light-beam oscillographs, cameras, and other devices were abandoned in favor of magnetic-tape recorders. For they are not only precise, economical, compact, and easy to operate but are also available for instant data playback and analysis at any time.

The final major component, the harmonic-wave analyzer, separates a complex waveform—as obtained in blade vibrations—into its individual frequency components. This way each component and its amplitude can be made known. The analyzer presents on a scope a plot of frequency versus amplitude of each frequency component. In safety monitoring of blade vibrations, this is the only accurate method of measuring the stress level of all vibration nodes which may be excited.

Data Reduction

The instant playback and unlimited analysis features of data recorded on magnetic tape offer a tremendous advantage in jet-engine and missile testing. For in these areas, test conditions can't be reproduced. Once the data are on the tape, however, the test can be rerun for detailed study as many times as might be desired.

In fact, the tape playback speed can be reduced by as much as 20 to 1 so that rapid transients can be recorded on low-response oscillographs for more precise study.

The fact that playback can be repeated simplifies the analysis. For instance, certain significant points of the recording frequency, level, or phase can be analyzed in detail, one at a time. However, the tremendous number of recordings on a single test (on one test alone, 17 miles of tape were recorded) hastened the need for an efficient method of data reduction (photo). (Waveshape and a Fourier analysis of the waveshape are the basic data required.) A skilled group of technicians together with a complex group of instruments—harmonic-wave analyzers, electronic filters, cathode-ray oscillographs, level amplifiers, and many others that they are trained to operate—interpret the data.

Combined Skills and Effort

Much of the equipment for stress-analysis projects General Electric obtains from outside firms, mainly from small businesses. Projects of such magnitude are frequently beyond the scope of these firms. But by tackling the big tasks and risks ourselves, solving the complex problems involved, and then breaking the job down into specialized assignments, we can use the skills, ideas, and specialized products of supplier companies.

This teamwork combines our own special talents with the enterprise and ingenuity of many other companies. The nation's defense needs are met and opportunities opened for many of the country's smaller and more specialized businesses.

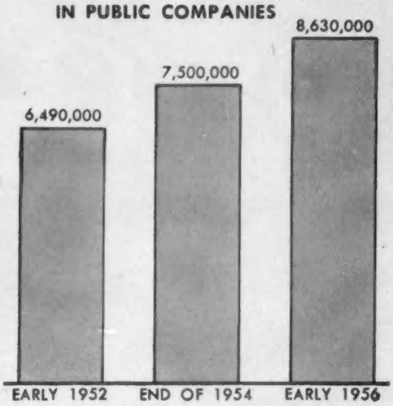
Great Savings

Experimental stress analysis now plays a major part in developing better jet engines for our national defense and tomorrow's jet transports. Its application saves many millions of dollars and months of development time. In some instances, expensive research components have been saved from total destruction during initial tests by careful monitoring of stress values.

And with continued use of experimental stress analysis, the development of new applications—limited only by man's imagination—will have still greater significance to the designer of tomorrow's jet engines. Ω

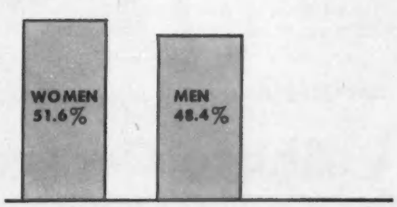
Women Capitalists: The ladies' viewpoint is significant—even though they may disagree on a point of interest at an annual share-owners meeting. For today women account for more than half of the total share owners of industry.

GROWTH OF SHARE OWNERS IN PUBLIC COMPANIES

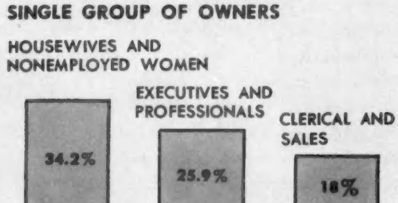


CORPORATE ownership is widening because more than 500,000 people, on the average, are becoming share owners each year.

WOMEN OUTNUMBER MEN, AND . . .



. . . HOUSEWIVES ARE LARGEST SINGLE GROUP OF OWNERS



SHARP CHANGE took place since 1952 when women share owners rose by almost 40 percent to 4,455,000. Men number 4,175,000.

NEW DIMENSIONS OF AMERICA'S ECONOMY—I

The Ever-Broadening Ownership of U.S. Business

***Review* STAFF REPORT**

One of the most important and promising changes taking place in the nation's economy is the emergence of the "Main Street Capitalist"—people in all walks of life, in every part of the country, and at all income levels who share in the ownership of American industry.

For instance, people owning shares in publicly held companies numbered 8,630,000 at the end of 1955, according to the *1956 Census of Shareowners* prepared by the New York Stock Exchange. This constitutes a 33 percent rise from the Brookings Institution figure of 6,490,000 for early 1952 (illustration, top left).

In addition to the share owners of publicly held corporations, some 1,400,000 people own shares in privately held companies *only* — bringing the total share-owning population to more than 10 million. And some 100-million people comprise the *indirect* share owners through their savings in life insurance companies, pension funds, mutual savings banks, and other financial institutions that invest part of their funds in equity securities.

Share owning isn't restricted to those with large incomes—almost two thirds of America's adult share owners have household incomes of *under* $7500. And one out of every 12 adults owns shares, with women outnumbering men (illustration, lower left).

This broadening base of ownership in American industry helps destroy the myth that stock investments are for only the wealthy or the privileged. The owners of the world's richest nation—using the most successful economic system ever devised—are products of every part of the country, every occupation, and every walk of life. To see a cross section of America's share owners, turn the page . . .

EMPLOYEE Mrs. Ann I. Shem, Milwaukee, received her first shares of stock through her company's stock plan. She likes being a "capitalist," now invests through a broker.

PENSIONER Mary M. Hammond, Hudson Falls, NY, supplements her income with dividends, stays active in community affairs.

GROCERY-BOY Larry Cichy, Schenectady, received his first share of stock on his 11th birthday, and another at Christmas.

NEW DIMENSIONS OF AMERICA'S ECON MY

Share Owners

The seven people shown on these pages are representative of the eight-million Americans who invest their savings directly in the stocks of publicly owned corporations. For example, more than 370,000 men and women have chosen to directly invest part of their savings in General Electric.

These seven also typify the 100-million Americans whose savings are invested indirectly in companies through insurance companies, mutual savings banks, pension funds, and other forms.

COMPANY PRESIDENT Arthur A. Gallagher heads E. A. Gallagher and Sons, a Philadelphia trucking concern. Gallagher is typical of the many small businessmen who are suppliers to large business enterprises as well as owning shares in them.

NEWCOMER Jeffery P. Shore, Utica, NY, was only two days old when he became a share owner in an American corporation.

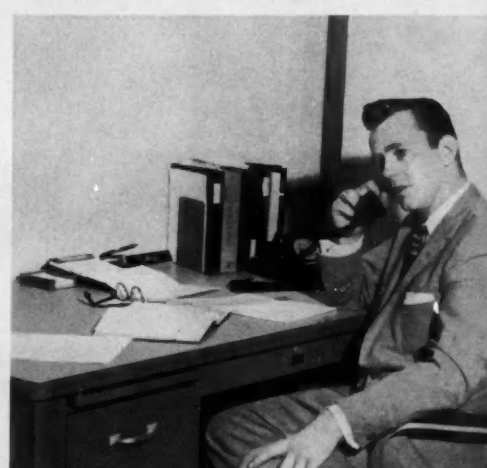
NEWSPAPER REPORTER Amy Jane Bowles recently invested in stock. Miss Bowles works for the Holyoke, Mass., *Daily Transcript*.

Come from Every Walk of Life

Perhaps not every one who invests understands the creative role his money plays. Most investors know, however, that they are practicing the basic American principle of thrift—putting their savings in some investment with the purpose of obtaining a return. Only a few, perhaps, completely understand how their invested dollars will come back to them in the form of better goods at lower prices; in more jobs, higher wages, and added leisure hours for employees; in new schools, churches, and hospitals; and in all the things that spell progress not only in dollars but also in increased human satisfactions.

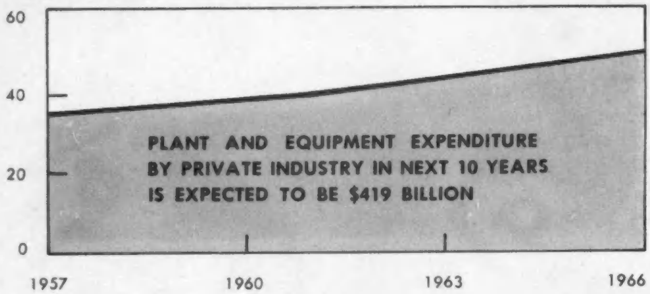
Of varied callings, the share owners pictured here clearly demonstrate how widely the ownership of American industry is spread. America's economy truly constitutes a "People's Capitalism."

But broad as this ownership may be, even more Americans must become share owners in industry. The *why* is described on the next page . . .



ENGINEER Ralph E. Walker, Schenectady, participates in the General Electric Savings and Stock Bonus Plan for employees.

NEW DIMENSIONS OF AMERICA'S ECONOMY (Concluded)



Industry's 10-year plant and equipment needs of $419 billion—to meet the productivity challenge of America's growing economy—are only one reason . . .

Why America's Economy Needs More Share Owners

There are three reasons why it's important to increase the number of Americans who own shares in industry.

First is the tremendous demand for new capital investment to fulfill the needs of a growing economy. American industry faces a productivity challenge that can be met through an acceleration of the rate of capital investment in new and more productive plants and equipment (photo, right).

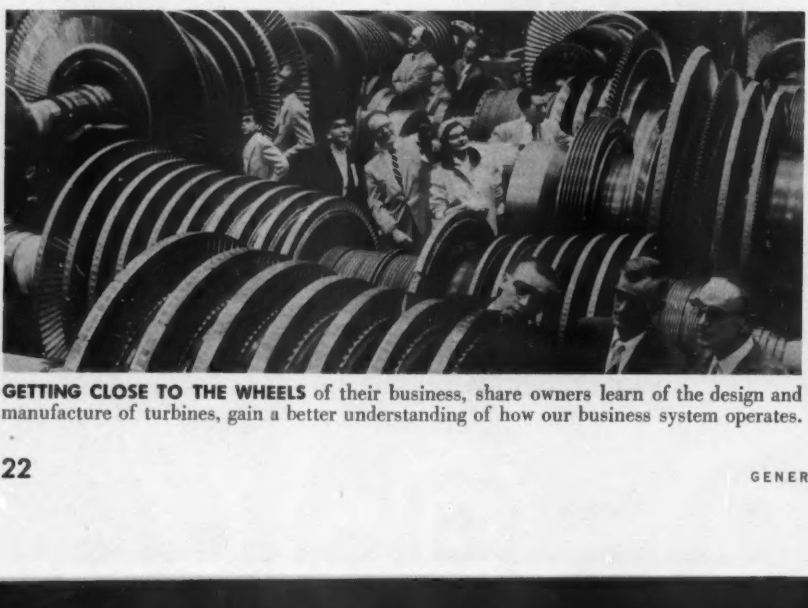
A total of $419 billion in new capital will probably be needed during the next 10 years (illustration). If we want to take advantage of the potential the future holds, the problem of how to interest greater numbers of average Americans in investing part of their savings in industry must be solved. The alternative consists of relying excessively on borrowed money or perhaps government financing.

The second reason is the ever-present need for increased understanding of our competitive-enterprise economy.

With only one adult in 12 owning shares, the remaining 11 find share owning a relatively untested venture. This means that the great majority of American people are missing the opportunity to identify themselves more closely with American enterprise—and thus share in its progress and better understand its aspirations and objectives.

Wide ownership will give more people an understanding of our economy (photo, below) and further participation in its success.

The third reason, and a most important one to each of us, is the direct reward of share ownership to the individual—a share in today's profits through dividends as well as future income from a share in tomorrow's profits. Ω



GETTING CLOSE TO THE WHEELS of their business, share owners learn of the design and manufacture of turbines, gain a better understanding of how our business system operates.

PROGRESS in automation is possible because of investments of many share owners.

INSTITUTE OF THE AERONAUTICAL SCIENCES

By S. PAUL JOHNSTON

At the end of 1956, the Institute of the Aeronautical Sciences (IAS) completed its first quarter century of service in America. First patterned after Great Britain's Royal Aeronautical Society (RAeS), the Institute originated with a group of scientists who felt that the aviation industry in this country deserved an organization of its own. Lester D. Gardner served as its secretary until his retirement in 1946.

But since IAS's founding in 1932, the classical concept of an aeronautical engineer—a man concerned largely with patterns of air flow over airfoils in wind tunnels or the behavior of stick-and-wire structures under stress—has changed. Today aeronautical science includes practically every field of scientific endeavor. Thus you'll find it almost impossible to define an aeronautical engineer in simple terms.

Aircraft and missile designers now deal with the most sophisticated aspects of mathematics, physics and chemistry, metallurgy, aeromedicine, and human engineering. Already well into regions of atomic and nuclear phenomena, their scope is almost limitless. And along with these innovations, the original ideas on the IAS's size and the character of its services have also changed. Its staff alone has grown from one to 80.

Disseminating Information

To meet varying requirements, the Institute must anticipate every subject of interest to its members. Security restrictions frequently impose obvious difficulties. Clearly, the national interest precludes open discussion of design developments of great interest to potential enemies.

Many subjects can and should be discussed, however. No nation can claim proprietary rights to basic scientific information. Our nation's opponents are well versed in all the fundamental sciences. Promotion of discussion in these fields presents our only hope of keeping ahead. Although this imposes difficulties on IAS program planners, they still fulfill the needs of the membership for fundamental information.

Professional groups *must* discuss certain subjects under restricted conditions. More and more frequently, the Institute conducts classified conferences closed to general attendance at both national and regional levels. These conferences range from specialist meetings to national meetings. For such meetings, the attendees must meet strict security requirements—including certification of personal clearance and need-to-know—by their own organizations and the cognizant military authority. Special arrangements always made under official supervision at the meeting place guarantee security of the discussion—both in physical arrangements and proper identification of participants.

Meetings

Each year the Institute holds two general meetings—one in New York in January and the other in Los Angeles in June or July. These meetings span three or four days each. The programs cover the entire range of subjects of interest to members and frequently include collaborative sessions with more specialized societies. The 1957 Annual Meeting in New York comprised 26 separate sessions; more than 90 technical papers were read and discussed; registered attendance reached more than 2500. Such general meetings are largely unclassified.

Between regular meetings, shorter sessions on more limited subjects occur. During March for the past 12 years, a symposium on aircraft propulsion has taken place in Cleveland—a natural location because of the proximity of the National Advisory Committee for Aeronautics' (NACA) Lewis Flight Propulsion Laboratory. This meeting now requires secret clearance. For the past three years, a special meeting devoted to discussion of turbine-powered air transportation has been held either in Seattle or in San Diego. This summer, a national naval aviation meeting, in collaboration with the Bureau of Aeronautics of the Navy, was held in San Diego. And later this year, a national symposium on weapons system management is slated for Dallas, Texas.

For many meetings, IAS arranges inspection tours at significant government research and development centers. Usually, these visits are classified and not open to general attendance. In recent years, selected IAS groups have gone to sea on aircraft carriers; inspected newer missile-carrying cruisers; visited missile-testing installations of the Army, Navy, and Air Force; and have been briefed at important research and development centers.

International Programs

During the past 10 years, the IAS has expanded its collaboration with scientific societies overseas. This fall the Anglo-American Conference—held every other year—will convene in England for its sixth meeting. Recently, IAS and RAeS jointly assisted in the formation of the Canadian Aeronautical Institute. A number of collaborative meetings have been held and more are planned. Contact with corresponding societies in France, Germany, and Holland has also been established.

During the past four years, the IAS has worked closely with the Advisory Group for Aeronautical Research and Development (AGARD) of NATO. Represented at AGARD general assemblies, the Institute has participated in many committee and panel activities—particularly groups concerned with the compilation and distribution of technical documents throughout the Western World.

This year IAS embarked on a new program to materially broaden its scope. Supported by the Daniel and Florence Guggenheim Memorial Fund for the promotion of collaboration in the aeronautical sciences, the Institute takes a leading part in the organization of a series of International Congresses in the aeronautical sciences.

All nations of the world, regardless of military or political interest, will be invited to participate. Representatives from 10 foreign countries met in New York City earlier in the year for pre-

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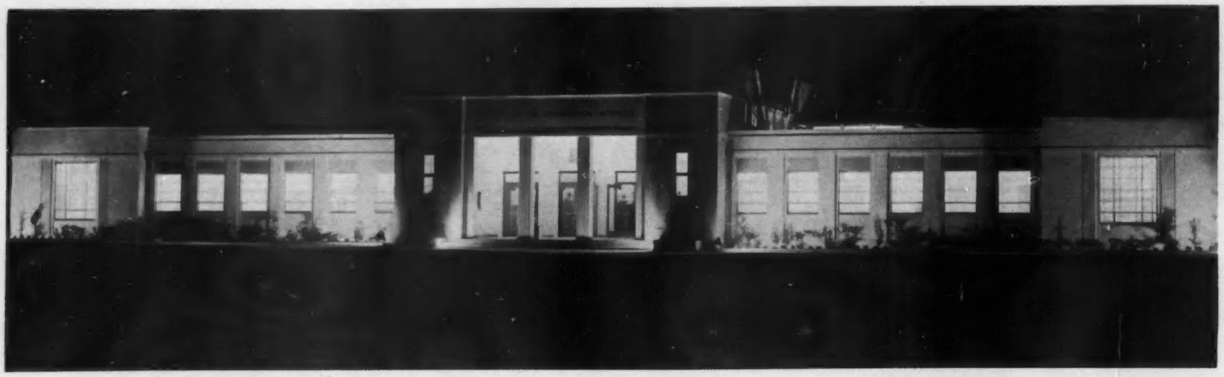
Mr. Johnston serves as Director of the Institute of the Aeronautical Sciences.



IAS'S SAN DIEGO BUILDING houses the Aircraft Technical Film Indexing Project and technical representatives of aircraft industry units.

liminary discussions, and again in Paris on May 30 for specific talks leading toward the organization of a First World Congress to be held in Madrid, Spain, in mid-September of 1958.

Membership

Rate of growth and membership stability measure the success of any professional society. Without recourse to national membership campaigns or selling programs, the Institute's membership progresses steadily from year to year in an almost straight line (illustration, opposite page).

The initial roster of 400 has grown steadily to more than 13,000 graded members—a figure that includes practically all the outstanding aeronautical engineers and scientists in the U.S. and many other countries. And IAS's 3000 student membership provides a good potential against future requirements.

To maintain high membership standards, a nine-man committee carefully screens and passes on the qualifications of applicants. Operating as a watch dog, this committee's mandated interest dwells in quality rather than quantity of membership. Grading of IAS members by this committee in accordance with educational background, experience, and attainment establishes recognition of professional standing. A total of 214 Fellows—the highest regular grade of member in IAS—appeared on the roster at the beginning of the year.

Honorary Fellowship represents the highest honor given by the Institute. Annually the Fellows elect by secret vote one American and one non-American. The only necessary qualification: eminence in aeronautics. The Honorary Fellows include such men as Orville Wright, Glenn Martin, Charles Lindbergh, and Harry Guggenheim.

Student Activities

Realizing it must satisfy the requirements of not only the defense research worker and the practicing engineer but also the aeronautical student, the Institute has established more than 80 student branches. These represent every school and university in the country offering aeronautical engineering courses.

Outstanding engineers and scientists lecture before these student groups—part of the Institute's great effort to provide programs of direct interest to the student. And IAS's Film Library—sponsored and partly endowed by Gabriel Giannini—furnishes interesting and instructive technical motion-picture films for student meetings.

Organization of eight regional student conferences at schools and universities occurred this spring in key areas throughout the United States. Students and faculty advisors met and exchanged views, and opportunities arose to inspect aeronautical manufacturing facilities and make first-hand contact with senior members of the industry.

At each conference, a jury of local engineers evaluated the papers presented, awarding cash prizes both in undergraduate and graduate categories. First-prize papers from the regional meetings were submitted to the Institute's national headquarters, and a committee of the country's top-ranking aeronautical scientists selected one in each classification for a national prize.

The one-half-million-dollar Minta Martin Aeronautical Fund makes the regional meeting activity and the national prizes possible while also providing for the publication and distribution of prize papers and other outstanding student reports.

IAS's unique position in the aeronautical field has alerted its officers and council to the industry's long-range need for more and better engineers. Because of this presently acute situation, Institute interest now goes beyond the student already enrolled in college aeronautical courses, reaching down into the high-school and prep-school level.

Publications

IAS's regular publications include the monthly *Journal of the Aeronautical Sciences*—the standard scientific reference work for the industry at home and abroad in the past 25 years. It carries no advertising, only scientific papers of the highest caliber. And ranking specialists in many fields make up its editorial committees. Circulation now reaches more than 7000.

The *Aeronautical Engineering Review*—an engineering magazine—covers current developments in all areas of Institute interest. Distribution constitutes 17,000 copies monthly. Many of its technical feature articles originate in IAS meetings and discussions. Engineers in industry contribute others directly. The *Review* includes a monthly index of current publications in the aeronautical field with a special up-to-the-minute section of abstracts of the world's literature, partly supported by a contract with the Air Research and Development Command (ARDC) of the U. S. Air Force. This monthly feature is now being translated into French and German for distribution through ARDC channels throughout Western Europe.

This same publication also carries news of Institute members and their activities. Receiving its support directly from advertising, it successfully competes with commercial publications. And both its editorial and advertising coverage continue to expand.

In addition to regular monthly publications, IAS publishes an annual catalog and directory of airborne aeronautical equipment. This publication specifies all kinds of parts, materials, and accessories for aircraft and guided missiles. Also, under the sponsorship of the Sherman M. Fairchild Publication Fund, IAS puts out numerous reports, reprints, and preprints of papers from its own meetings and other sources. In the nine years of the Fund's existence, some 625 titles have been published and more than 140,000 copies distributed at a nominal cost to the members.

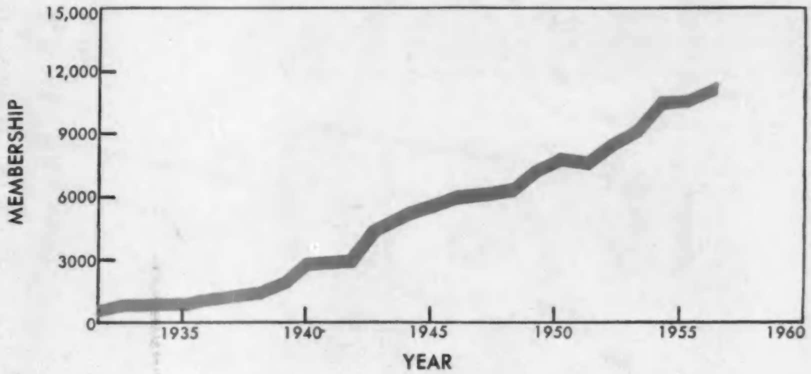
To assist in their student activities, the IAS staff prepares two widely distributed booklets. Since 1954, three editions of a vocational guidance manual, *The Engineering Professions in Aviation*, have gone to high-school and college counselors. This booklet furnishes the basic facts and figures of the aviation industry, including its size and location plus classification of various engineering and scientific openings. Each job category is described in detail: educational and experience requirements, duties, and current salary range. Also a list of schools and universities offering aeronautical subjects along with a brief description of their courses can be found in its pages.

Another publication attracts the high-school student's attention, directing him toward a scientific career in aeronautics. Interested students in all major high schools throughout the country have received more than 120,000 copies of *Your Career as an Engineer in Aviation*.

Awards

The Institute has become the custodian of six awards recognizing professional standing in various aeronautical categories. . .

- Octave Chanute Award—for a notable contribution made by a pilot to the aeronautical sciences
- John Jeffries Award—for outstanding contributions to the advancement of aeronautics through medical research
- Robert M. Losey Award—in recognition of outstanding contributions to the science of meteorology as applied to aeronautics
- Sylvanus Albert Reed Award—for a notable contribution to the aeronautical sciences resulting from experimental or theoretical investigations having a beneficial influence on the development of practical aeronautics
- Lawrence Sperry Award—for a notable contribution made by a young man to the advancement of aeronautics
- Water-based Aviation Award—for meritorious work in the design or operation of water-based aircraft leading to advances in performance or utility.



INSTITUTE MEMBERSHIP progresses steadily without recourse to national membership campaigns.

Lectures

IAS also supports in whole or in part several memorial lectures. The most important of these—the Wright Brothers Lecture presented annually on December 17 for the past 12 years—marks the anniversary of the first airplane flight. The Vernon C. Lynch Fund finances it.

IAS cooperates with the Massachusetts Institute of Technology (MIT) in the presentation of annual Minta Martin Lectures in several parts of the United States by the Jerome Clarke Hunsaker Professor of Aeronautical Engineering at MIT. And in connection with the International Congresses in the aeronautical sciences, a Daniel and Florence Guggenheim International Memorial Lecture in the aeronautical sciences will be presented.

An IAS Fellowship in flight-test engineering directly supports one phase of aeronautical education. An anonymous donor has provided for one or two outstanding graduate engineers to continue advanced study in this field. To date, Princeton University has given these courses, but the Fellowships are not restricted in location. They may be made available at any school offering a suitable course in the subject.

Library Services

The IAS—one of the few professional engineering societies maintaining its own libraries—considers the supply of up-to-date information to its members important enough to warrant the maintenance of specialized technical collections.

Two principal centers are maintained, one in New York and one in Los Angeles. The New York Library contains a large collection of current technical and engineering literature from all over the world and one of the most important collections of historical material in the country. Since 1947 it has published *The Aeronautical Engineering Index*, an annual guide to the technical literature.

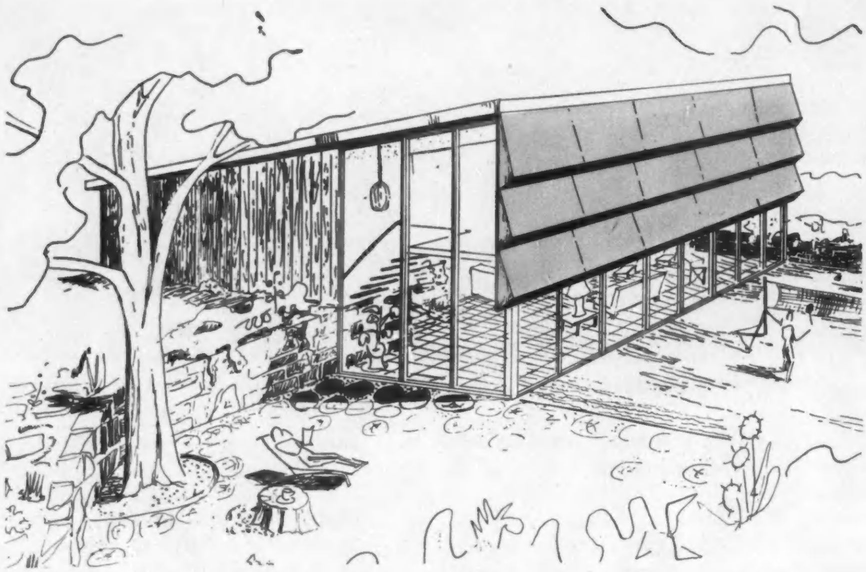
In Los Angeles the Pacific Aeronautical Library functions largely to keep the aviation industry in the area technically up to date. During the past year, this unit with its relatively small staff serviced more than 50,000 requests.

Physical Facilities

In its early years—1932 to 1939—IAS occupied a small suite high up in Radio City in New York. It soon moved to larger quarters in Rockefeller Center; but by 1945, it had outgrown the midtown location. The Institute then made plans for its own building in New York City. Backed by contributions from the aircraft industry, the present headquarters at 2 East 64th Street was purchased and refurbished to meet the needs of the organization. It houses National Headquarters and IAS's New York libraries and aeronautical museum.

Near the end of World War II, the aviation industry on the West Coast had expanded to justify a western facility for the Institute. Local contributions made possible a Western Region headquarters building in Los Angeles in 1948 and a smaller facility in San Diego (photo, opposite page) in 1949. The Los Angeles building—a focal point for all technical aircraft activities in the area—houses the IAS Western Region Office and the Pacific Aeronautical Library. It contains a modest collection of historical books and model aircraft and a full-scale replica of the *Wright Flyer* of 1903.

IAS looks forward to providing its essential services to the aeronautical industry for many years to come. Ω



As a contemporary architect sees it, the long, low look of today's home might be complemented by sunshine concentrators. Not appearance but cost prohibits home-power generation today.

Long Shot: Competitive Electricity from Sunshine

***Review* STAFF REPORT**

It will be a while yet before you power your home workshop with current from the sun. Perhaps a generation, maybe a century—it can't be forecast with much assurance. But the possibility is intriguing. Compared with the earth's puny fossil fuel reserves, the sun's energy is boundless—it requires no mining, no refining, no distribution.

Scientists have devoted much study to solar energy in recent years. As much is known about it today as is known about nuclear energy—and commercial production of power by fission became a reality this summer. However, a dollar barrier blocks the parallel growth of solar-power generation. You *could* run your power saw on sunshine today, but it would cost you about 54 cents per kilowatt-hour, or some 14 times what you presently pay.

Solar Study

Mounting curiosity about sun power recently led to the formation of a study group in the General Electric Research Laboratory under the direction of Dr. Kenneth H. Kingdon. The members of this group were Drs. Garland M. Branch, David L. Douglas, John F. Flagg, Richard E. Halsted, and Lewis R. Koller. A number of other scientific organizations are conducting similar investigations.

And in 1954 the formation of the Association for Applied Solar Energy grew out of the widespread interest in exploring the sun's possibilities. Meetings in sunny Tuscon and Phoenix the following year attracted delegates from 37 countries. The meetings were billed as "The first broad consideration of all aspects of solar energy." The world's first periodical on the subject, *The Journal of Solar Energy Science and Engineering*, appeared only a few months ago.

One of the questions continually asked at the first scientific meetings was, "Is there enough sun energy falling on the roof of the average house to meet the house's electrical needs, assuming we could convert it?"

Today's answer provokes further interest: Based on measurements of average incident sunlight in the Temperate Zone, about 580 kw-hr of heat energy falls daily on an average roof of 1075 square feet. Assuming a 5 percent efficiency in converting this radiation to electricity, the average house would generate 29 kw-hr of power daily if fully equipped with roof collectors. This amounts to 2½ times the power consumption of the average American home.

Alternate Power Sources

If world consumption of coal, oil, and natural gas continues to double every 25 to 30 years, as seems reasonable, then in 100 to 125 years the reserves of these conventional fuels will be exhausted. Hydroelectric and tidal power could supply only a trifling fraction of our power needs.

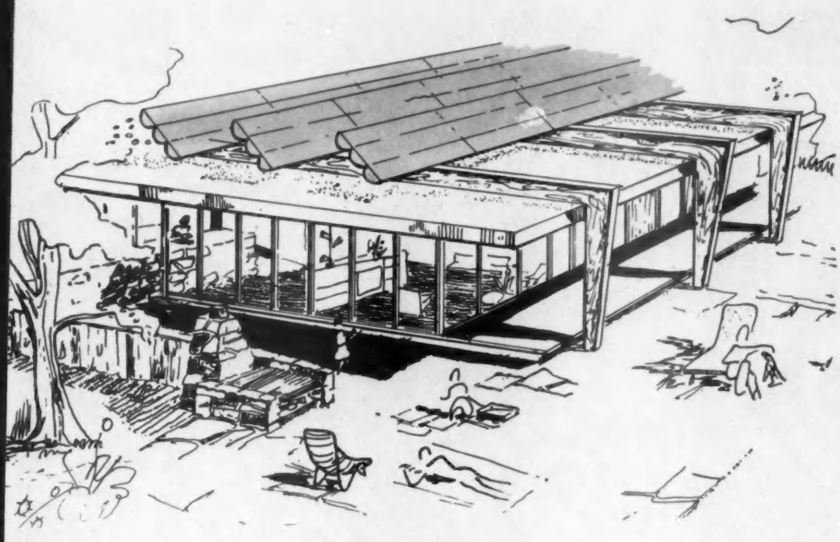
Of course, the nuclear processes of fission and fusion provide alternative energy sources. While nuclear fission now produces energy, we don't yet know how much of our future energy needs can be met from this source. It will depend on the supply of uranium and on how efficiently this uranium is *burned*. Presently known reserves of uranium would suffice to produce electricity for as long as 200 years beyond the exhaustion of our fossil fuel supplies, assuming maximum efficiency of utilization.

Because plentiful deuterium would be consumed, energy from controlled nuclear fusion would be virtually inexhaustible. Not possible today, the controlled release of fusion energy may be achieved in 20 years according to estimates. Thus we can't evaluate the potential of fusion energy on a basis comparable with conventional fuels, fission energy, or solar energy.

Application Principles

The necessary science and technology now exists to use the sun for heat and electricity. Only the conversion of solar energy directly to chemical energy through photosynthesis isn't completely understood (Box, page 28). What then are some of the factors limiting solar-energy application?

The amount of solar energy reaching the earth's surface daily in the Temperate Zone averages 0.54 kw-hr per square



foot. The heat reaching the earth's surface every four days equals the amount in our entire reserve of fossil fuels. This energy is distributed over a broad spectrum ranging from the visible region to the far infrared. We receive the greatest part of this energy as radiation in wavelengths between 0.4 and 1.4 micron.

Solar radiation has two important characteristics: its abundance and its diffuse distribution. Its abundance eliminates the need to conserve energy in attempting to utilize solar radiation. Efficiency is important only if it leads to lower costs; the successful utilization process will be the one with minimum capital cost, regardless of efficiency.

With solar energy already distributed to individual consumers, let's consider its utilization by them. A central station to produce solar electricity, for example, would suffer economically from transmission costs added to an already expensive system. In this regard solar and nuclear power differ basically; for nuclear power costs will tend to decrease as the plant size increases. Thus nuclear and solar power serve different markets in part, and their simultaneous development doesn't necessarily bring them into competition.

Home Generation

Rather than a large central station which would possess no obvious economies of construction or operation, let's think about a plant for generating electricity directly in the home. Because of distribution costs, electricity at the home may be worth as much as six times the value at the central-station plant. The difference may be exploited to the extent that it permits the highest capital cost for the installation.

The system's main components would comprise a bank of photovoltaic cells (Box, page 29) suitably connected with storage batteries. We can reduce the cost by concentrating the solar energy optically with simple mirrors, for they presently cost much less than photovoltaic cells. However, the optimum degree of concentration must be carefully determined; very high concentration, as in a solar furnace, would make the system too expensive. We would need a mechanical means of following the motion of the sun accurately and a cooling system for photovoltaic cells.

A study of the concentration problem has led to a favored arrangement in which the collectors are cylindrical parabolic mirrors with their axes extending east and west. We could adjust the tilt of the mirrors manually from time to time to follow the seasonal change in the altitude of the sun, but no diurnal adjustment of the system will be necessary. The photovoltaic cells are mounted in a long cylinder placed at the focus of the mirror.

A typical arrangement consists of a cylindrical mirror with a 20-inch opening and a 1-inch-diameter photocell placed at the focus. This would give a 20 to 1 concentration ratio for the incident sunlight. Under these conditions the operating temperature of the photocell would be a permissible 260 F, and mirror costs would be in a satisfactory range. A transparent protective screen provided with openings for the natural or forced circulation of cooling air would probably cover the bank of mirrors. These mirrors might be mounted on the house roof, along a side wall, or perhaps even as a free-standing fence separated from the house.

Silicon is the best of the photovoltaic cell materials presently available for solar-electricity generation. It will operate at elevated temperatures although at decreased efficiency, thus enabling its use in a solar-electric system employing sunlight concentration. The efficiency of a silicon photovoltaic cell decreases markedly with increasing temperature; its assumed efficiency of 5 percent at our operating temperature of 260 F is roughly half the efficiency at room temperature. Obviously, the development of new materials with improved high-temperature operating characteristics will be of great importance in solar-electricity generation.

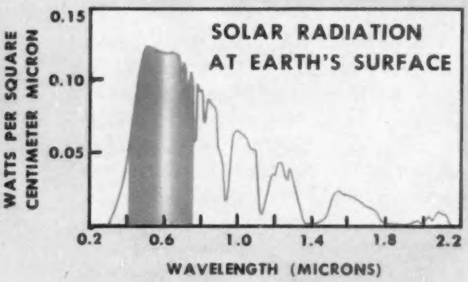
Storage System

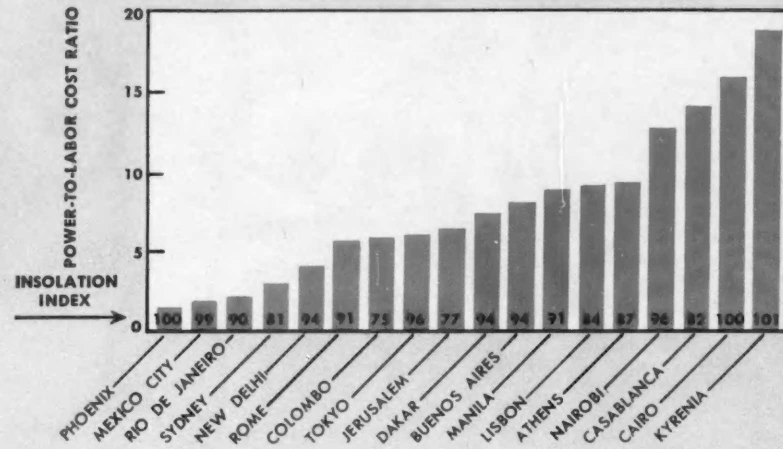
A major problem in any use of solar electricity arises from the intermittent nature of this energy source. Not only nighttime but also periods of cloudy weather require the storage of excess energy generated during light periods for subsequent use—recoverable as electricity. The storage battery provides a technological if not presently economic solution to the problem.

To function as an energy-storage system for a solar-electric plant, a storage battery must be capable of undergoing repeated charges and discharges over a long period of time.

The amount of storage that must be provided depends on the expected duration of sunlight. In the Boston area the battery must hold, it seems, about an 8-day average charge to provide continuity of operation. With less than this storage capacity the battery would become depleted; and the available supply from the solar generator would be insufficient to maintain the full-house load. If a battery life of 2000 charge-discharge cycles could be achieved, then if the discharge occurred on an average of every 8 days, the battery should last 16,000 days, or about 40 years. This is longer than the design life of present-day batteries. But for an area such as Phoenix, Ariz., only 3-day storage would be required. This necessitates a battery lifetime of about 15 years, which equals those used in telephone exchanges and emergency power supplies.

RELATIVE ECONOMICS OF SUN POWER





Sunlight conversion currently appeals most in world areas where power costs are relatively high. Sunlight collectors, such as the parabolic mirror, appear necessary for economical use of the photovoltaic process.

Abundant Sunlight May Be . . .

Because the character of the storage system is so vital to the performance of a solar electric system, scientists have investigated battery materials, costs, and design. They see a possibility of some reduction in the cost of storage batteries for this purpose within a few years.

Energy Economics: Concentration . . .

To evaluate the economics of photovoltaic solar-energy conversion, let's first make some design assumptions in these areas: the concentration of solar energy, efficiency of photovoltaic cells, selling price of electricity to the individual consumer, and the capital charges on the plant investment.

At what location in the world might solar electricity be appropriately considered as an energy source? A study by the Stanford Research Institute of 18 cities between 40 degrees north and south latitudes shows that the integrated, or cumulative, amount of solar radiation per year over the entire belt varies only from 75 to 104 percent of the integrated amount of radiation at Phoenix.

Thus the average kilowatt-hour per square foot per day in the United States applies to a substantial number of sites where individual photovoltaic plants might be located. To give adequate power in winter, these plants must be sized for less than the average flux of incident power. A reasonable design basis for the plant might be 60 percent of the average power flux; thus the plant would be designed for 0.3 kw-hr per square foot per day.

. . . Efficiency . . .

The yield of electricity depends on the conversion efficiency of the photovoltaic cell. The energy needed to produce an electron-hole pair determines the fraction of incident solar energy intercepted by the cell. In addition, surface reflection losses and dissipation of energy within the cell limit the maximum theoretical efficiency in sunlight. For

APPLYING SOLAR ENERGY TODAY

So far man has harnessed only a trifling sample of the enormous supply of available solar energy. Of the total amount of the sun's incident radiation, the clouds reflect about 35 percent back into space each day. Of the remaining 65 percent getting through to the earth, most goes into the rainfall and evaporation cycle and into heating the globe itself. To man much of this energy is wasted because rainfall at sea and the desert heat bring us no apparent benefits. While photosynthesis absorbs a large portion of our solar energy, again much of this is wasted because jungle growth benefits man so little.

In putting the sun to work, science has made small inroads in two areas: heating devices and photosynthesis.

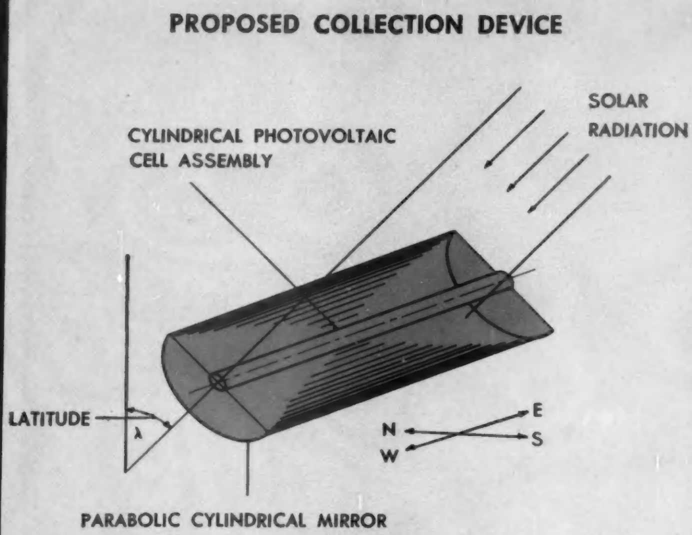
Heating

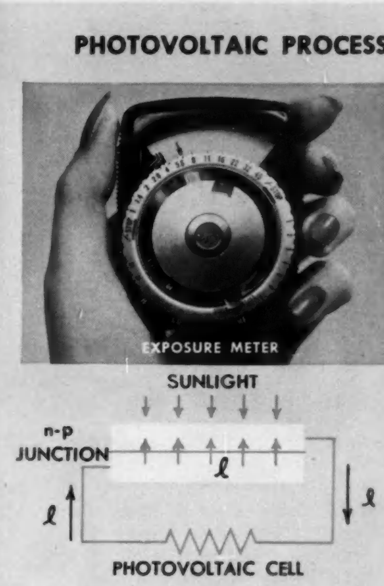
Examples of solar heating include solar stills, solar furnaces, water heaters, cookers, and other radiation concentrators. We can produce electricity from this heat in conventional ways: by generating steam to drive a turbine-generator or by heating thermocouples to produce direct current.

As a source of energy, these methods may have their special applications; but as a means of producing electricity, both methods have serious limitations. These stem from the low-duty cycle—maximum of 8 hours of sunshine per day—and low efficiency caused by back-radiation from the collector.

Photosynthesis

While photosynthesis probably constitutes the most complex process involving sunlight, we can understand most parts of it, duplicating them in the laboratory. But its application beyond the ancient ends of agriculture must await our grasp of one final vital link in the process—the mechanism of water's dissociation into H and OH ions. Its solution still eluding scientists everywhere, this seemingly simple but thoroughly baffling problem is one of those held up to students as an incentive to earn advanced degrees and enter research work.





. . . Collected and Converted . . . . . . in a Silicon Cell

silicon the limit is about 20 percent at room temperature, with efficiencies of 10 to 11 percent presently achieved.

Assuming a 5 percent conversion efficiency at 260 F, the yield of electricity will comprise 0.015 kw-hr per square foot per day.

. . . and Cost

At 4 cents per kilowatt-hour to the individual consumer, the yield of electricity from one square foot would be worth 0.06 cents per day, or 21.9 cents per year. The plant supplying this power must not cost more than $1.81 per square foot if, as is the practice in utility plants, a capital charge of 12 percent per annum is made on the plant investment. If mirrors concentrate the sunlight by a factor of twentyfold, the permissible investment will be $36.20 per square foot. The mirror may cost 40 cents per square foot, or $8 per square foot of photovoltaic cell surface. The remaining cost, $28.20, may be apportioned between the battery and the photovoltaic cell.

If the battery must hold a four-day average charge, this amounts to 0.06 kw-hr per square foot of mirror aperture. Storage batteries presently cost about $100 per kilowatt-hour. As a result, the battery will cost $6 per square foot of mirror aperture, or $120 for the system with the twentyfold mirror concentration. Thus we have already exceeded the allowable $28.20. An economically feasible system necessitates a drastic reduction in the cost of the battery. If a sixfold reduction in battery cost is achieved, the expense for the 20-square-foot system would be: mirror $8, battery $20, photovoltaic cell $8.20. We assume that unitized construction of the components makes labor installation a small portion of the total installed-system cost.

How realistic are we in considering a sixfold reduction in the cost of the storage battery? The cost of the electrode materials actually participating in

HOW THE PHOTOVOLTAIC PROCESS WORKS

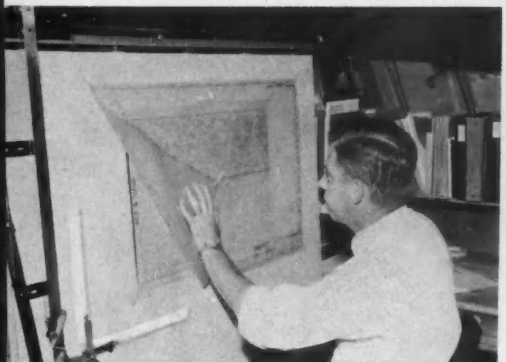
Radiation from the sun arrives in quanta, or packets, of various energies. In green plants these quanta split a water molecule into H and OH with the aid of a catalyst. Through succeeding steps involving reactions with CO_2, carbohydrates are built up in the process called *photosynthesis*. If of the appropriate energy, the light quanta may cause the formation of electron-hole pairs in various materials. The separation of these electron-hole pairs by an internal field leads to the photovoltaic effect.

The selenium photoelectric exposure meter—a familiar example of a device for generating electricity directly from sunlight—converts sunlight to electricity with an efficiency of less than 1 percent. This fact combined with its limited lifetime in full sunlight renders the cells unattractive for solar-electricity generation despite its low cost. The higher efficiency and longer life of silicon photocells provide a much more economical source of solar power.

Production of electricity from a silicon photocell requires the formation of a *p-n* junction in a single crystal of silicon. Normally a poor electric conductor, silicon can be rendered conductive by adding to it a trace of such an element as arsenic or phosphorus containing one more electron than silicon. Conduction takes place by *electrons* in this material, designated as *n*-type silicon. Conversely, adding an element containing one less electron than silicon, such as boron or gallium, results in *p*-type silicon, which conducts by positive charges, or holes (absence of electrons). A single crystal of silicon can be made part *p*, part *n* type. This junction forms the boundary between the two parts.

A barrier electric field at the *p-n* junction keeps the electrons on the *n* side and the holes on the *p* side. The absorption of light by the silicon creates an electron-hole pair. The field of the junction forces electrons into the *n* side making it negative and holes into the *p* side making it positive. This establishes a voltage difference, providing electric power. Because no chemical change occurs in the silicon photovoltaic cell, its lifetime is not limited; its energy is derived entirely from the incoming light quanta. In full sunlight its open-circuit voltage measures about 0.6 volt.

CONCLUDED ON PAGE 43



A tenth-inch incremental grid drawing (above) serves as basis for mechanized fabrication and assembly of wiring boards. Prepared from a dimensionless drawing, it's one of many new concepts in an automation program of integrated mechanization.

DRAWING-TO-TAPE PROGRAMMER automatically converts information to a common language tape. Operator merely aligns drawing on the programmer, sets selector switch for the proper hole size, and depresses the stylus beneath his thumb at the proper hole location.

Automating on a Pay-As-You-Go Basis with

Taking the broad approach to automation as an integration of mechanized processe piecemeal allows you to quickly convert from limited to large-scale production o

***Review* STAFF REPORT**

Popular concepts of automation tend to embrace one of two equal but opposite errors. Usually, people either think of automation as exclusively a factory program—applicable only to mass production—or as a kind of magic—something dreamed up in a futuristic laboratory and set apart from the mundane problems of making a profit.

How General Electric's Light Military Electronics Equipment Department (LMEE) at Utica, NY, entered the automation field is a saga of neither. Rather, it exemplifies how one aggressive management team recognized the need to automate their facilities on a practical basis.

This in itself isn't unusual until you consider the wide range of products LMEE produces for the Armed Forces: radar, sonar, communication, and data-handling equipments plus other related devices and systems. And whether component or system, the bulk of these products are slated for airborne applications.

Why Automate?

As any primer on production will tell you, two factors motivate automation: improving your competitive position and increasing company earnings. Yet Herman F. Konig, LMEE's General Manager, sees still another and equally important motivating force—industrial preparedness.

"We have to do today's job today," says Konig, "but we also have to be able to convert from limited job-shop quantities to large-scale production in the event of an all-out national emergency. Automation, then, is the means to this end."

And so the problem that LMEE's management faced from the very beginning was not "Should we automate?" but rather "*How* should we automate—and *how* soon?"

Logical Approach

In essence, LMEE approached automation as over-all systems planning, reduced to practice on a piecemeal pay-as-you-go basis. You can more readily understand this approach in the light of what automation means to the engineers and managers concerned.

You'll find the word *automation* only in the most recent dictionary editions. Perhaps this explains why people often think of automation as synonymous with mechanization, a term restricted more precisely. Konig and his engineering-management team accept the definition of Prof. H. Martin, Rensselaer Polytechnic Institute: "Automation is the accomplishment of any work task by a power-driven *integrated* machine without direct application of human energy, skill, or intelligence." They distinguish mechanization as the "accomplishment of separate process objectives by power-driven machinery."

Thus automation results from both

TAPE-READER AND PUNCHING MECHANISM quickly revises data from the original tape. New and other unchanged data from the original are punched simultaneously.

AUTOMATIC HOLE-PIERCING MACHINE operates from tape fed into a reader. With the wiring board positioned under punch process, the decoder selects proper punch and directs the piercing operation.

Over-All Systems Planning

and putting the plan into operation
more complex products.

mechanization and integration. You achieve the first level when you integrate two or more mechanized processes. Each successive step of integration then establishes a higher level of automation. When do you reach the ultimate level? When the programming of operations, the operations themselves, maintenance of quality level, and the continuous flow of material under process are all accomplished without human operators.

With the concept of automation as *integrated mechanization*, you begin to see the logic of the systems approach. Of course you can reach some levels of automation by indiscriminately integrating mechanization projects. But the ultimate level can be reached only if you plan and design individual projects with an over-all program in mind.

LMEE's approach to automation: Plan on an over-all systems basis; reduce to practice by mechanizing piecemeal any operation economically justifiable on its own merits.

Alert Task Force

To put the philosophy into practice, LMEE established an Automation Task Force in January 1954. It comprises a representative from engineering, quality control, manufacturing, and finance.

As a continuous function, this group investigates automation and mechanization possibilities throughout LMEE. The men of the Task Force not only collect, analyze, and classify data but also recommend projects for automation to the general manager and his associates. And once accepted, the responsibility for carrying out these projects is assigned to LMEE's operating sections: engineering, manufacturing, finance, marketing, and employee and community relations.

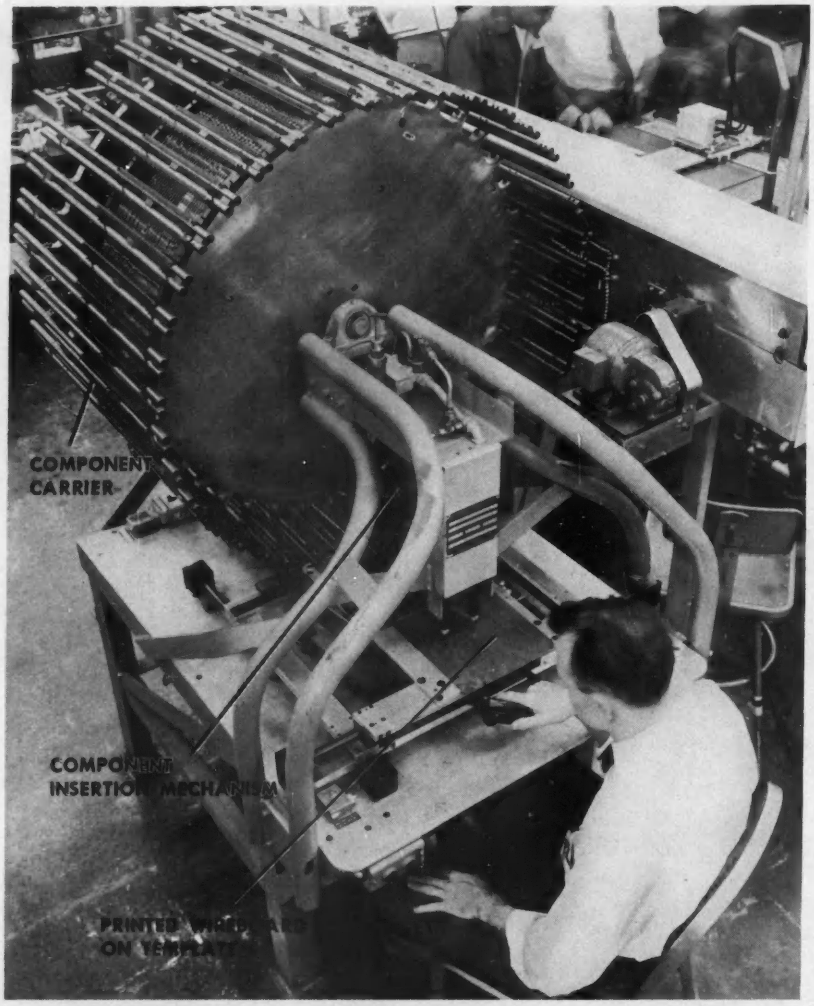
To management the Task Force presents data, having three objectives in mind . . .

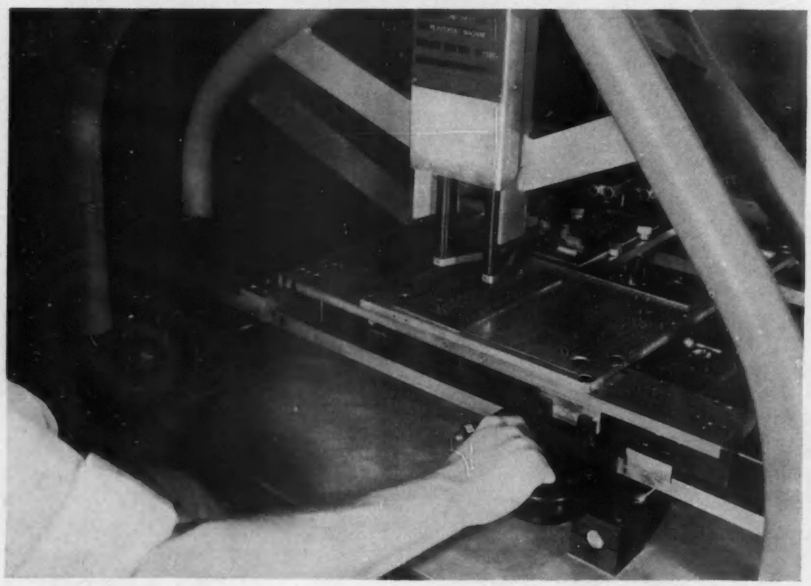
- Establishing criteria for automation and insuring compatibility of the department's operations with these criteria
- Finding *general* areas that can possibly be automated and determining which of these will bring the fullest immediate return
- Substantiating that *specific* automation projects are possible within these areas and evaluating the potential return for the effort expended.

Implementing the Plan

Initially the Task Force engaged in an orientation period. During that time, its four members educated themselves broadly in the field of automation and overcame the communication problem that naturally arose from their diverse backgrounds. Next they conducted an over-all systems study that included 1) analysis of flow charts for all departmental routines, 2) a departmental manpower analysis, and 3) a survey of current outside automation projects.

"Despite our diversified job-shop operation," reports Arthur F. Maynard, engineering representative and Task Force chairman, "significant patterns of volume in factory and office justified a continued effort to automate. You establish or increase volume patterns by grouping work tasks that require repetitive efforts and by applying engineering design standards." Design standards, Maynard explains, increase the number





COMPONENT-PLACEMENT MACHINE, a sequential type (top), automatically rotates racks that carry electronic components under a single placement head (close-up, lower).

"Standards establishe

of similar jobs to be done so that development of automated flexible machines becomes justified economically.

"These machines are technically possible now," adds Edwin Suuronen of manufacturing. "They can be designed for programming by punched tapes or punched cards that tell the machine what to do." Suuronen emphasizes another important point: When the engineer designs the products specifically for assembly or fabrication on automatic machinery, he necessarily designs a simpler, neater product that would be easier to make—even if the work were all to be done by hand. Thus design for automation in itself proves to be a good thing. It results in reduced costs and improved products even before installing the automatic machinery.

Reduction to Practice

Standards established in several design areas permit grouping tasks that involve repetitive effort. This justifies specific automation projects for work in sufficient volume.

For a job-shop factory, the usefulness of this technique can be readily comprehended from a few examples.

Take the design and manufacture of printed wiring assemblies—the common denominator of most LMEE products. Individual printed boards differ both as to function and configuration. But they are generally made from the same basic materials, using the same factory processes. Special-purpose machines for assembling identical boards are impractical because the small quantities don't justify the cost. Likewise the wide range of operational demands for assembling a variety of boards, designed from a purely functional standpoint, would also make the development of such machines technically impractical and prohibitive in cost.

"The answer," says Lester E. McCabe, the Task Force quality-control specialist, "lies in standardized design for printed wiring assemblies—an integrating link between engineering design and the manufacturing process. Because of standardization the manufacturing people can treat printed wiring boards as items of large-scale production." This way, McCabe continues, they can justify the construction of general-use programmed machines capable of meeting the limited operational requirements of uncontrolled functional design.

…n design areas permit group tasks involving repetitive efforts."

A one-tenth-of-an-inch incremental spacing will serve as an example of the standardized design McCabe refers to. The result: Limiting hole locations to only 100 predetermined possibilities from an otherwise almost infinite number in any one-square-inch area.

To drafting alone, the value of this standard can't be overemphasized. It eliminates the need for specifying hole locations by dimensions: a pencil mark on graph-like paper having the grid pattern will suffice (photo left, page 30). Because hole locations furnish a common denominator in detail drafting, fabrication, and assembly, you can readily use a programmed position device in all these functions. This common denominator—location—is then integrated through these functions by the media of punched tape or punched cards.

An Advance Engineering group built a drawing-to-tape programmer (photo right, page 30) for producing this common-language tape directly from dimensionless drawings. Operators align drawing with programmer's x and y axes (Cover photo, right), position a stylus over the hole location, set a selector switch at the indicated hole size, and depress the stylus. Location of the stylus on the x and y axes, the hole size, and a machine-actuate-command are then automatically binary coded and punched into a paper tape. In essence, the operator then has a tape that contains all the information normally needed by the fabricating machinist while punching holes in the printed wiring boards.

A second machine—comprising a tape reader and punching mechanism—enables the operator to quickly and easily revise the original tape (photo left, page 31). This he feeds into the reader and, except for revisions, automatically duplicates a new tape. To make revisions, the operator depresses a cancel bar to prevent obsolete information on the first tape from being punched into the duplicate tape. Then he punches the revised information into the new tape. Returning the machine to duplicate control, he allows the unchanged information remaining on the original tape to be punched automatically into the revised tape.

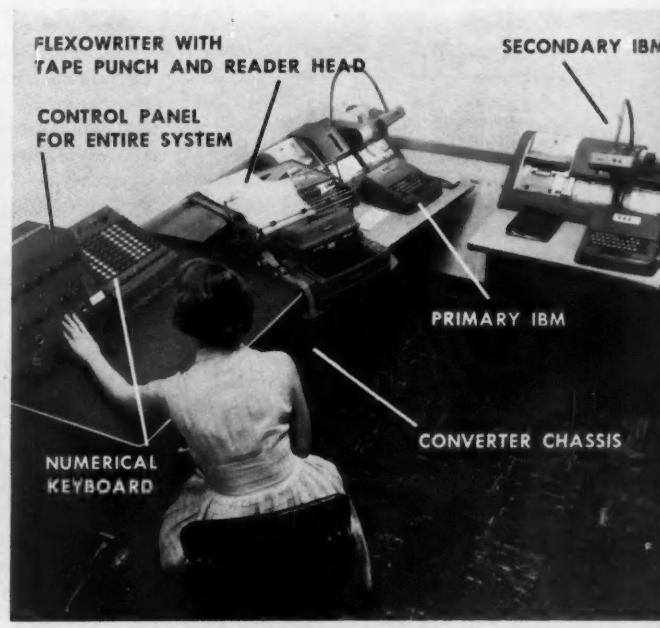
With these duplicate tapes, he then programs the automatic hole-piercing operation (photo right, page 31). A special punch press has a hydraulically actuated positioning device and a tape decoder. The decoded information in the punched tape controls the position of the wiring board under the press, selection of punch size, and the actual piercing operation.

Besides the incremental spacing standards for printed wiring boards, the Task Force also recommended standards for placement of components. These predetermine the possible positions for mounting the components on the boards. Based on these design standards—plus the fact that 75 percent of the components have basically the same physical form—engineers developed a machine that automatically places the components (photos, opposite page).

Also, in the planning stage is a tape-programmed control system that will eventually replace operators who formerly positioned the wiring boards and triggered the placement process.

Continuing the logical process of automation, chassis frames were standardized by applying the one-tenth-inch incremental standard to their design. This allowed simplifying the cut-off operation for varying lengths of square metal tubing that form the framework. Developed to perform this operation, an automatic cut-off machine (Cover photo, left, and photo, left) utilizes a positioning mechanism. Identical to that used on the tape-programmed punch press, it provides for future tape programming of the complete cut-off operation.

SQUARE-TUBE CUT-OFF MACHINE automatically cuts square hollow tubes to appropriate lengths for assembling into electronic chassis.



SPARE-PARTS AUTOMATION SYSTEM utilizes punched cards, tape, or keyboard inputs and produces typed documents.

"Automation should be regarded as a gradual, evolutionary process."

A significant but frequently overlooked area in automation, the Task Force believes, is that of testing the products manufactured. Formal design standards are not yet determined in this area. But as a result of an evaluation made by the quality-control group of LMEE, development of automatic test equipment has progressed.

Their analysis proved that the work in the test area could be divided into three types of effort: 1) routine repetitive work of inspection testing for circuit continuity and proper component assembly, 2) routine and repetitive but more complex functional testing to insure proper operation of the unit with power applied, and 3) the neither routine nor repetitive job of trouble shooting and repairing the units that fail to pass the test.

Advances in reducing total production-test time result largely from three functions of automation. First, automation segregates routine repetitive effort. Second, it reduces functional test time by automatically locating defects during inspection testing. And finally, it speeds testing operations at all levels. With quality control in mind, McCabe feels that the results of these efforts are sufficiently encouraging to provide stimulus for more advanced work. "Some fully automatic functional test systems," McCabe points out, "have been developed and evaluated through use in actual production. The effect of this equipment on production testing is a bright prospect for the future."

Handling Data

Data-handling efforts at LMEE include recording, transforming, and communicating information as well as instructions. You will recognize this as a primarily important area because it also integrates engineering design with manufacturing.

In this field, LMEE's approach again adheres to the same program of systems study and reduction to practice on a pay-as-you-go basis.

The systems study made by the Task Force shows that 26 percent of the labor force handled approximately 6-million documents a year—spread evenly across *all* functional areas. And so, the question again before the Task Force wasn't "Should we automate?" but "*How* can we automate most advantageously?"

Ultimately, the program's objective is to use computers for handling data. An intermediate program is in operation meanwhile to reduce the over-all data-handling system to common-language machines that use punched cards and tapes. According to Russel P. Miloto, representing finance on the Task Force, this decision was influenced by 1) the revolutionary transition period preceding direct conversion to computers and 2) the need to integrate the already automated payroll unit into the over-all system. Additionally, the intermediate step provides quantitative data to support existing qualitative data for evaluating LMEE's ultimate computer requirements, and for evaluating the present systems' efficiency as well—a practical step. For the intermediate systems' punched-card output can be utilized as the input for the ultimate computer system.

Primarily, LMEE's effort in establishing the intermediate system was applying automatic data-handling machines procurable in the open market. Of course, machines available commercially didn't always satisfy the specific requirements of a routine. In this instance, engineers developed control devices that integrated individual machines into a system to perform the routine.

An example of automation in data handling is a new engineering release system (Cover photo, top). Designed to reduce clerical effort, it shortens the cycle of releasing engineering data to manufacturing. Also, it creates documents that allow information to be automatically reproduced and reused. This system indicates some of the universal objectives for all LMEE data-handling programs.

Standard punched-card processing machines make lists, duplicate cards, and carry out similar operations. From such a system you have the advantage of flexibility in sorting and combining like data for direct transmission to the point of usage. What's more, the punched-card outputs of this system become the inputs that set the stage for further automation of such functions as procurement, production, fabrication, cost analysis, and spare parts.

You get an idea of the advantage gained in integrating several standard machines into a system from LMEE's automation of spare parts. The system they developed provides great flexibility and comprises two key-punching machines, a tape-programmed typewriter, an auxiliary keyboard, and a control unit (photo right, page 33). It will operate using punched cards, punched tape, or keyboard inputs—to produce typed documents, punched cards, and punched tape as outputs of the system. Inputs and outputs can be varied or interchanged.

Specifically, the system types the documents used as the customer selects spare parts. After he makes his selection, the system further documents data to finalize and incorporate the spare-parts requirements into the contract. Punched cards, produced as a by-product of the automatic typing operations, serve as inputs to the automated processing of related functions.

Looking Ahead

In the factory of the future, you'll find areas where the entire transition from design concept to shipment of the tested product can be completely automated. Computers will interlink the various functional areas as well as process many of the scheduling and control functions.

Automation should be regarded as a gradual, evolutionary process. Its most important effect will not be on the level of employment but rather on the qualifications and functions of employees. No one should entertain the slightest doubts about automation: it can no more create unemployment than could mechanization. History proves that increasing technology creates new products and opens new fields so rapidly that the demand for workers increases steadily.

Indeed, factories of the future will be hard pressed for manpower, and automation appears to be their only salvation. And for a simple reason: This nation must increase its production about 40 percent in the next 10 years. We know, too, that the available work force will increase only about 14 percent. Thus only through the widest use of new and better machines can we achieve the fullest measure of employment and a higher level of living.

The ultimate level of automation is a difficult thing for any industry to accurately predict. "At LMEE," says Chairman Maynard, "it will depend entirely on the extent to which we can integrate automated data-handling and production functions. The results achieved thus far more than justify our past efforts. Ω

You Can Communicate More Skillfully

To effectively gain cooperation of people, put yourself in their place. Then orient your message to their needs and interests, making your pitch short and to the point by appropriate techniques.

By C. A. CHURCH

Do you have trouble expressing yourself to others? do your employees react slowly to your recommendations? do you frequently feel frustrated because people don't readily buy your ideas and concepts? in short, do you repeatedly suffer from failures in communication?

If so, you have plenty of company in every profession. For the very word *communication* is widely thought of as in itself unlocking the way to a wide variety of teamwork attainments. But the communication process is more than mouthing words, evidenced by the confusion, misunderstanding, and frustration that exists unabated despite the mountains of mail, the endless meetings, and the infinity of articles.

You needn't despair, however, there is a solution. Communication difficulties usually arise because people tumble into one or more of the three common pitfalls: They 1) have a fuzzy purpose, 2) confuse their message with techniques, and 3) take the audience for granted. A little time spent in learning about the communication process beforehand will not only avoid the pitfalls but also conserve thought, time, and effort for all people involved.

WAYS THAT YOU CAN AVOID . . .

. . . COMMON COMMUNICATION PITFALLS

- **Have a definite purpose.**
- **Keep the message and the technique separate in your thoughts.**
- **Realize that your audience may not necessarily give you its full attention unless you make your presentation brief, understandable, and worthwhile from your recipient's viewpoint.**

The Communication Process

As a prerequisite to effective communication you should have at least a nodding acquaintance with the nature of the process. For our purposes, let's think of communication as "the flow of intelligence via a specific connection between two minds, one of which has a message to transmit, and one of which is capable of understanding and willing to listen." Based on this definition, the communication process breaks down into four simple elements: a communicator, a message, a connection, and a recipient.

For this process to work effectively, certain relationships must prevail. The elements must be matched, so to speak. For example, the communicator must be well-informed in some fields, have a desire to communicate, and have a purpose in mind. In addition, the recipient must be able to understand, willing to pay attention, and capable of responding. Moreover, the connection must be one that bridges the communicator and the recipient, and the message must be appropriate to the occasion.

Another important consideration involves the end result desired from a particular business communication. You can use the communication process for one or more of the following: 1) to inform, 2) to stimulate thought, 3) to persuade, and 4) to induce a response.

The first two end results are in effect built into the communication process. The recipient, once he has agreed to listen or read, can scarcely help being informed or stimulated. When you want the last two end results, you use the communication process to sell something to someone.

The psychology and techniques of selling permeate all elements of the process. When the sale does not materialize, you should reappraise the communication process, of course. However, a reappraisal of the market conditions and the selling psychology is equally important. Many people hear "the word" but don't act accordingly.

Fuzzy Purpose

Most people have the knowledge, urge, and ability to expound copiously on a pet subject. With little or no forethought, words flow easily; and the experience is gratifying. If you yield to this temptation, you're in the fuzzy-purpose pitfall. Likely result? A confused, impatient, or drowsy listener—and little fruitful communication.

The fuzzy-purpose pitfall is devastating in several respects. If you lead off without an apparent reason for talking, the recipient is likely to turn his attention elsewhere. In addition, you may talk too long about irrelevant subjects, and to people who can't take action. Without a definite purpose, any other outcome is a coincidence for you have little basis for intelligent selection or organization of information.

Even when you clearly define your over-all purpose for the communication process, the objectives of related parts may still be vague. For example, you should be able to check off on your

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A SYSTEMATIC WAY TO BETTER COMMUNICATION

- **Define the Problem**
- **State the Purpose**
- **Formulate Your Basic Message**
- **Orient to Your Audience**
- **Establish Your Connection**
- **Measure the Response**

fingers the specific results desired from a meeting, publication, or speech. Well-defined purposes make formulation of the message easier and its meaning clearer to the recipient.

Confusing Message with Techniques

You often hear the statement, "We should have a periodical," or are asked the question, "Isn't it time to have a meeting?" The essential question should be, "Do we have a message?"

For some strange reason, many communication-minded people tend to confuse their message with the means of transmitting it. Perhaps it's because as recipients all of us have received forceful messages via a letter, meeting, or movie; thus we associate the two so closely that the thought of one suggests the other. This tendency also persists among communicators because after the exchange is over the only tangible evidence remaining may be a three-color brochure or an 8 x 10 glossy photograph.

A periodical may indeed be desirable and a meeting essential; but, unless the message is suited to the kind of connection in question, little communication takes place. Well-meaning people who fall into the pitfall of confusing the message with techniques create an immediate effect: a busy paper mill and a thriving business for the supporting activities. Don't become so preoccupied with techniques that you lose sight of your purpose with the result that the recipient becomes an excuse or a mere statistic. The recipient is then worse off than before—he must not only spend more time in meetings and sorting mail, but he also becomes burdened with puzzling out whatever of importance the communicator has on his mind, if anything.

Taking the Audience for Granted

To suggest the cavernous extent and treacherous aspects of another pitfall—taking the audience for granted—let's look briefly at the mental preoccupations that can and do logically befall communicator and recipient about to communicate.

The communicator likely will be wrapped up in his own specialty and assume others are equally interested, feel he has all the answers, try to give everyone the full treatment, and judge situations from his viewpoint. Certainly he hopes the recipient will be interested, be knowing, want help, respect the communicator, and respond logically.

Quite in contrast to these fond hopes, the recipient likely will be preoccupied with his own problems, be a busy person in his own right, have established habit patterns, have already formed an opinion, be emotional about making a change, and be unlike any other person.

Moreover, he probably hopes the communicator has the forethought and courtesy to make his pitch short and snappy, talk about the recipient's problems, use understandable terms, present useful information, provide alternatives, and suggest practical courses of action.

With such a divergence in interest and expectation, you can easily see what communication trouble may develop if you take the recipient for granted.

"Organized approa

Preface to Better Communication

Communication can't be bought by the cartful—as you would select a commodity at the supermarket. Business communication involves indefinite combinations of people, varying situations, and multifarious purposes; thus a particular instance usually differs in theory and in practice from every other one in some respects. The techniques employed may be identical, but the communication process will not be the same.

If you wish, you may buy the services of a communication specialist, who can be most helpful. However, this in no way relieves you of your leading role in the process—unless, of course, you desire to abdicate this function to the specialist.

A businessman, an engineer, or anyone else is well on his way to more effective communication when he recognizes that he is an indispensable part of the process, that each instance differs, and that the process will respond to good planning. Once you accept this, you will almost perforce think and act in a pattern to avoid the common pitfalls. Even so, an organized approach will not only speed the process but also guard against mental lapses. You may find helpful six general sequential steps (Box) that are amplified in the following paragraphs.

Define the Problem . . .

Your need to communicate suggests a problem involving people. To communicate intelligently, you must know in what respect the people are part of the problem. Who is involved? are they uninformed or misinformed? is their attitude hostile or indifferent? do they act in the wrong way or not at all? Answers to these and related questions are basic to effective communication, providing focus and direction for your planning.

Because each individual has his own peculiar way of doing things, your communication should be in terms that are meaningful to him and his particular job for maximum impact. Unless you define your purpose carefully, you may end up orating vague generalities to a motley gathering and wondering why nobody is listening. A detailed analysis provides a sound beginning for effec-

...vill not only speed the process but also guard against mental lapses."

tive communication that gives each recipient the specific information he needs and can act upon.

. . . State the Purpose . . .

When you cannot entirely solve well-defined problems by the communication process, you may wish to supplement your program with other activities. Even when communication offers the complete solution, it may take a variety of messages over an extended period of time. Clear-cut statements of purpose should define what parts the communication process will accomplish, what each message should accomplish, who will communicate them, and what audiences will be reached.

Detailed statements of purpose are a must if you engage the help of specialists to plan, prepare, and execute the communication portion. Without it, an outsider has no basis for intelligent selection or organization.

. . . Formulate Your Basic Message . . .

An abundance of misinformation and a dearth of factual information characterize most communication problems. This generalization applies to both communicator and recipient. On this premise, you should screen your fund of information for unsound assumptions, speculation, and wishful thinking on your part. Closely examine your facts because facts collected to prove a particular viewpoint or quoted out of context can boomerang. Document your information. Is it representative? will it be palatable to various audiences?

Bias removal and fact checking sometimes discredit parts of both the problems and the purposes that you have carefully prepared. Review them in light of any new knowledge.

Next, assemble additional information pertinent to the problem, the purpose, and the recipient. You can now formulate the over-all message. Prepare constructive factual material to include the theory, basic considerations, salient benefits, pertinent explanations, proposed action, and how to carry it out. This becomes the basic reference from which you draw specific messages; thus fine embellishments or crafty shades of meaning are unnecessary. You are talking to yourself or your associates; so husband your psychological ammunition for the time when you engage your audience.

. . . Orient to Your Audience . . .

No two recipients are exactly alike; their interests, their problems, and their temperaments differ. Audiences differ too. Moreover, the ability of individuals, and thus of audiences, to comprehend and respond varies with levels of responsibility, kinds of work, and years of experience. Department managers usually aren't interested in the same processes as line foremen. Design engineers ordinarily have different work objectives than research scientists.

The impact of a product change has one effect on the sales engineer and quite another on the piece-rate worker. When the message passes down through a business organization, these differences are of especial significance. The relaying at each level is a communication process in itself and should be conducted accordingly.

Thus every communicator would do well to systematically appraise each of his audiences beforehand on the basis of such questions as: What are the mutual problems and interest areas? how can the audience benefit by giving attention? what is the depth of subject matter comprehension? are individual recipients able to respond as expected? how can response be made easy and simple?

Armed with the information elicited by this approach, you can then select and use from your basic reference material only that which is akin to your particular audience on a specific occasion. Such a selection process, if done honestly, usually will reduce several file drawers of "very important" information to amazingly few pages—a most happy result for both you and your audience.

. . . Establish Your Connection . . .

If circumstances have not already established the connection, you should now plan, select, and implement your connections. Depending on the problem, the purpose, the message, and the audience, the connection may be oral or written; man-to-man or in groups; a letter, a bulletin, or a motion picture; a one-shot affair or a campaign.

Whatever the form, you can now indulge a bit in your favorite communication techniques—whether they be copies of the competition's or personal preferences—without jeopardizing the message. If your message is sound and well oriented, your audience will suffer through or even enjoy almost any vehicle.

Except for extremely clever and talented communicators, day in and day out business communicators tend to submerge techniques to the message. Connections and their associated techniques, as any thoughtful communication specialist will tell you, aid in transmitting your message. But accord them thought and attention only to that degree.

. . . and Measure the Response

Sharp business managers and good engineers recognize the need for measuring results. The fact that communication results defy precise measurement points up even more the need to systematically appraise the response.

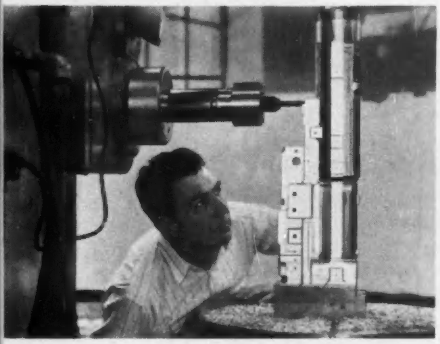
An analysis of the response can be particularly revealing and helpful in improving the effectiveness of both repeat performances and new programs on other subjects. Pretesting and dry runs also provide guidance but are no substitute for critical review.

Measure the results and not the connection. Don't ask your audience: "Did you like this meeting?" or "What did you think of that speech?" The movie may have been heart-rending and the brochure beautiful; but, if the audience doesn't remember or act upon the message, the whole affair was time and effort poorly spent. Generally speaking, people in business are rewarded for getting results—so spend your communication dollars accordingly.

Do What Comes Naturally

Communication, old as mankind, takes place naturally and continually and everyone participates—either as a communicator or a recipient. You can't readily segregate business communication into a neat little package and hand it to or blame it on someone else. It needn't become a big production that only a specialist could handle; nor need a good communicator be a thespian or an author.

Clear thinking and a forthright approach seasoned with a dash of practical psychology suffices in the great majority of instances. The simple systematic approach helps you—the everyday communicator—perform your job more expertly with shorter meetings, less paper, and a far better response from the audience. Ω



Complex techniques are among our subcontractors' important contributions. In Detroit, Pattern Products Manufacturing Company produces and designs precision products for industry.

How We Work with Subcontractors

By P. R. TOLLEY

Building a jet aircraft engine—as with a number of the other big building jobs that industry faces these days—represents too large an order for any one organization to handle alone.

Building the J47, the work-horse engine that has meant so much to American military aviation, took the help of more than 4000 separate companies. While General Electric directed the work, subcontractors—most of them small businessmen—assisted immeasurably in getting the big job done.

During the J47 production days, we learned a good deal about the requirements and techniques of working with subcontractors; we'd like to share that know-how. Work with subcontractors has two important aspects . . .

- The aid of resourceful and diversified groups is a *necessity*. Big jobs are seldom accomplished in industry today without substantial contributions from the large and small subcontractors who are available to all manufacturers.
- Work with these groups offers a real *opportunity*—a challenge for developing a two-way something-for-something mutually rewarding relationship in the nonmaterial as well as the material areas.

In General Electric it works out this way: The Company operates as a sort of informal, unauthorized sales agency for some or all of the abilities and facilities of its supplier businesses and the distributors and dealers beyond them. More than half of every dollar taken in is headed for a supplier.

While dealing with the variety of suppliers who helped turn out the J47, we saw dramatic evidence of our role as a stimulus for other businesses. We performed the highly productive and important economic and social function of creating new and different opportunities that wouldn't have been available otherwise. We took on the big tasks and big risks, breaking them down into the kind of smaller or specialized assignments that could be handled by other and usually smaller businesses in the supply and distribution fields.

In the process, our own internal functions were confined by competitive necessity and social desirability. For the advancement of the common interest of everyone concerned, we did the tasks that only we could do satisfactorily or that probably couldn't be done better elsewhere.

Our objective: To buy from outside suppliers when they offer goods and services more economically than we could produce them or even when, all things considered, they can produce as cheaply as we could.

We had two reasons for this approach: 1) We wanted to concentrate our efforts on those areas where we could be creative and make a distinct contribution. For people frequently fail when going into other people's businesses with no contribution to offer. 2) We believe that the American public expects a certain approach. In return for the great preference they have shown our Company, they rightly expect us to take on the big risks and break them up into smaller or specialized assignments. Many of these can be handled more effectively by other, usually smaller, businesses.

And our work in this direction is proceeding even further. Today the more powerful, more complicated J79 engine supersedes the J47. While the J79 is like a fine, modern wristwatch, the J47, by comparison, resembles a grandfather clock—big, rugged, and a bit crude. Progressing into this bigger and more complex work, we expect our circle of supplier businesses to develop and meet the challenges. Because of the opportunity we and others have given them, a number of small suppliers, through their own good management, have grown to become substantial institutions—a gratifying development.

Many common suppliers serve the whole aircraft industry. And each time any of us gives steady business to a creative and efficient supplier, we help the

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Mr. Tolley's career with General Electric began 22 years ago. He is Manager—Manufacturing Engineering, Assembly and Spare Parts Section, Aircraft Gas Turbine Division, Evendale, Ohio. His group provides equipment for producing and testing jet engines and spare parts and gives technical advice in this area to the Company's subcontractors.

whole industry offer a more attractive and effective product and service. Regretfully but conscientiously we should bring to an end any supplier relationships that are not giving value by the current standards. Because by shifting to more economic sources or means, we promptly serve the same good ends of contributing to and protecting the advance in values the industry offers.

A substantial segment of our manufacturing engineers devote themselves to technical consulting work with subcontractors. While working on detailed day-by-day improvements in materials and manufacturing processes, they constantly practice our over-all philosophy of our relationship with thousands of large and small businesses. Subcontractor relations on the J47 project met such success that many of them continue even though production has halted on that engine. We still provide spare parts for the thousands of J47 engines in active service.

The J79, which powers the fastest current production fighter and also the world's fastest bomber, is now scheduled for modification to commercial transport use.

Selecting Subcontractors

With these commitments, selection of qualified subcontractors becomes an important segment of this new production program; we constantly search for subcontractors who can help improve our product and service.

Determining what must be purchased is the first step in a production program involving subcontractors. This decision depends on the criteria you establish for your "make-or-buy" policy and may vary widely with different products. Thus you have the opportunity of placing the responsibility for a component where it should be—either with your own people or the vendor. Next you decide *how* to buy it. You have a choice of purchasing individual parts to assemble yourself or packaged parts to put together in a subassembly.

In deciding whether to make or buy, relative costs, lead times, and component functions deserve the most consideration. Static components lend themselves more readily to assembly from detail parts made by random vendors than do rotating ones. Such complex assembly as a compressor rotor containing more than 1500 parts requires a high degree of accuracy in the relationship of the various members. As a unit, it must meet certain dimensional, balance, and stability requirements. These can be best controlled by a single manufacturing source.

The final decision, when choosing the best supply source, involves many simultaneous considerations. At this point the new subcontractor has his first contact with our technical representatives. A formal appraisal of the prospective subcontractor is made before final selection, and his plant facilities are studied to determine capabilities and qualifications—no mere routine. And we welcome this opportunity to bring a new member into the family.

The facilities survey includes a breakdown of their employees; method of labor relations; and a complete review of their systems, paying close attention to their type of production control, tooling control, and quality control. Inquiries are made into the background of the firm, its management and business qualifications. Through this procedure, the information collected establishes the estimated value of a potential subcontractor to General Electric.

Company policy encourages small business to compete on an equal basis with big business. Subcontractors are assured of completely fair and unbiased evaluation in the manufacturing engineer's recommendation. This technical specialist recognizes the many skills and services of the small business firm. Over the years, thousands of these companies have become extremely valuable as suppliers and subcontractors.

Manufacturing Assistance

After placing the formal purchase order, the subcontractor continues to receive service from our technical representatives. Manufacturing engineering, on request, assists suppliers who experience difficulty in manufacturing. They review the subcontractor's methods, procedures, and techniques—suggesting corrective measures after a complete and thorough problem analysis. Experienced engineers from many fields—sheet metal, machining, tooling, casting, forging, and welding—are on hand. During the J47 jet-engine production program, thousands of reviews were made for the subcontractors. We make every effort to help the subcontractor eliminate problems in processing or manufacturing.

The manufacturing engineer also works closely with many other internal components. Also laboratory personnel assist suppliers with their problems in the fields of chemistry, metallurgy, and nondestructive testing. In addition, package design specialists are available for consultation on packaging problems.

In organizing the subcontractors into a successful operation, manufacturing conferences at our Evendale, Ohio, plant contribute desirable technical benefits. Subcontractors present an agenda of technical problems, submitting questions on the machineability of high-temperature alloys, forming characteristics, welding, heat-treating requirements, tool geometry, drawing interpretations, and other manufacturing aspects. The manufacturing engineer, in collaboration with many other engineering specialists, gives technical assistance and provides the answers to these many questions—a highly important function at the inception of the subcontractor's program.

Thus the subcontractor avoids many otherwise unforseeable pitfalls in starting his manufacturing processes. The subcontractor must be fully aware of the design requirements plus all the many manufacturing intricacies needed to satisfactorily process critical materials to high standards of quality.

Tooling

Tooling is vital to the successful manufacture of parts and assemblies. To properly predict the supplier's ability to meet both delivery schedule and quality requirements, we screen, review, and evaluate his efforts in tool design and tool procurement. To assure availability for scheduled needs, it often becomes necessary to assist him in programming his tooling.

A recent experience with one established subcontractor typifies this problem. In programming the production tooling, the tools were designed for use only on his newest, most expensive, and best machine tools. While this could enhance his quality level, an investigation disclosed that it would have been impossible for him to meet the schedule requirements due to lack of capacity. After re-evaluating his entire program, the manufacturing engineer recommended the redesign of a portion of the production tooling, utilizing less expensive and less frequently used machine tools. This solved the problem with no quality sacrifice.

One of the most rewarding tasks that we share with our subcontractors is tool control. We give them no blank checks for the special tools needed in our work. They submit a budget listing in detail the planned tools, their estimated cost, and quantities. We measure this budget with a very uncompromising yardstick: tools must be special within Air Force and General Electric definition, in sufficient quantity to meet the planned schedule, designed as the best compromise between simplicity and productivity, and must be no more expensive than absolutely necessary. As a set of tools, they have to represent good value and sound expenditure.

Having met all these standards, the tool budget gets tentative approval. After the tooling prove-out and production of acceptable sample parts, a final detailed invoice is submitted and reviewed. Final settlement with the subcontractor occurs only after approval of this invoice.

To standardize design when a project involves more than one vendor, careful and complete records are kept of all tool expenditures. And in the future, when engine models become obsolete in a production sense but still must be supported by a spare-parts program, these records again prove important. Orders for spare parts are frequently placed elsewhere than at the original production source, and often entire sets of tools can be reconsigned with little or no modification cost.

Subcontractors—Large and Small

Capacity programming receives special consideration from our engineers. In this role, we evaluate several subcontractors' suitability for making a specific part to meet a predetermined schedule, comparing the relative abilities of competing suppliers. Then we recommend one to our purchasing people.

Fulfilling the needs of a subcontract structure demands vendors of all kinds and capacities. Just as engine components vary from a few grams weight to hundreds of pounds, so do suppliers' shops run the gamut from small specialized shops to industrial giants with millions of square feet of factory space.

Almost invariably the larger engine components are placed with large plants —a perfectly logical procedure. For heavy work schedules that must go forward concurrently need extensive planning and engineering staffs. You'll also find this true for manufacturing; so many components must be in process at the same time that only a large plant can take the load in stride without committing most or even all of its facilities to one program—an unhealthy situation. And in considering financial responsibility, only a large firm can carry the burden of overhead, tool and material procurement, tool tryout, and pilot production without stretching its resources irretrievably.

A firm in Ohio offers a typical example of a large subcontractor. Already eminent as a manufacturer of automotive and aircraft parts, this company had no aspirations to design and build complete engines and set out to make itself as useful as possible to prime contractors. Its success supplies a chapter in America's industrial history. Without severe strain, it handled several engine-component programs simultaneously while building the proprietary products and components for still other customers. Only a company of this stature can employ large quantities of machine tools exclusively in one customer's interest and still have several times that many for others.

Though the large subcontractor offers many desirable features, small shops also play an important role. And while circumstances or their own wishes limit them to specific kinds of products, their proficiency in specialties often grows until it cannot be equaled in quality, price, and integrity of schedule. A small shop in Indianapolis exemplifies such a shop. Our plant-facilities survey report shows that they have been recommended to make small sheet-metal fabrications because of the vendor's fine reputation within this narrow field.

Flexibility characterizes the operation of this Indianapolis vendor. With two weeks' delivery commonplace, urgent orders have been met in as little as one week—including tool design and material procurement. At the same time quality is high and price competitive. Such companies in a hundred cities and towns cannot fail to find an important place in our subcontract structure. They provide substantial payrolls in both rural and urban communities—sharing with larger companies the task of making America strong.

On occasion, a vendor approaches us with a design change suggestion promising benefits in any of several directions: interchangeability, direct labor, material, weights, or safety.

A New Jersey company illustrates the mutual benefits that often follow. For years the manufacturer of rubber-lined flexible hoses for military applications, this company developed a new plastics hose material. Because rubber has a limited life and plastics deteriorates much more slowly and withstands higher temperatures, this development proved a singular contribution toward product improvement. Result: A production order for this supplier.

This leads to the ultimate contribution that an outside firm could make—the design for a novel device that overcomes a perplexing problem previously regarded as a necessary evil or that adds features to the product, enhancing its value or usefulness. The merits of such a design may be obvious enough to leave no sensible alternative to its adoption.

A company in Philadelphia that pursued a development program in carbon seals was approached by our engineers with a set of design requirements higher than any within its experience. Through constant and persistent effort the men on the staff designed, built, tested, rejected, and designed until they developed the present light weight, compact, and highly efficient seal. Immediate engine application led to production orders for this company.

Two-Way Proposition

From us the subcontractor receives the services of competent technical engineers and practical manufacturing consultants. The prime contractor benefits by having a wide scope of manufacturing experience and knowledge factored into the early stages of design. Thus we translate drawing-board requirements into practical manufacturing knowledge by originating and organizing the physical components quickly and inexpensively. This technical assistance helps provide for the expansion of a subcontract structure to include specialized vendors. We supplement the subcontractor's engineering staff by providing the necessary manufacturing and engineering knowledge needed to reduce the costly developments that a manufacturer constantly faces.

By helping the supplier, we help ourselves. That's what our total program of subcontractor relationships does in the long run. The results speak for themselves: improved products, on schedule, equal to quality requirements at every step. Ω

CREDITS

Page	Source
Cover	Don Morris
10–11	Burns Photography, Inc. Schenectady, NY.
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GENERAL ELECTRIC'S ANSWER TO . . .

Why worry about a CAREER?

HOW long before you'll be out of school and on your own? How many years before you'll be earning your own living?

It all depends, of course, on how much more education you're going to get—and, if you're a boy, on your hitch in service. But it may be sooner than you think. So let's go on to another question:

Have you any idea *what* you'll be doing for a living?

Maybe you don't care; maybe you'd rather not be bothered about it now. But if you feel that way about it, you could be wrong. For it might be a big help to you later, to think about it now, while you're in high school.

Here's why: Whatever you decide you like to do best for a living, or whatever work you decide will pay you the kind of salary or wages you want, chances are you'll be able to get what you want easier if you start preparing for it now.

By and large, there are two kinds of job: (1) those that require a special training or skill, and (2) those that don't. People who work can be roughly divided, therefore, into two similar groups: (1) skilled workers and (2) unskilled workers.

Time was when most of the people who worked were unskilled workers. Those were the days when life was comparatively simple—no big industries, not many machines or gadgets. Except for special craftsmen like silversmiths or stonemasons or bakers, there weren't many people with special training—people who could operate machine tools, or design bridges and automobiles and electric machinery, or figure out new chemicals like silicones and nylon, or design radios.

That wasn't too long ago, either. Fifty years ago there was no automobile industry; there were no airlines or home radios or electric refrigerators; most houses were lit with gas or kerosene; movies were rare.

Things Have Changed

Yes, it's only comparatively recently that we've needed skilled workers in such numbers—engineers, chemists, metallurgists, mathematicians, advertising specialists, machinists, draftsmen, etc. Things have changed so much, really, that all of a sudden we find we just about have to have specialized training of some kind, in addition to a good educational groundwork, if we're going to get anywhere at all. All the best jobs—and the best pay—go to the people who are specially trained for them.

So you can see it will be smart for you to cash in on this need for special skills. And you can make it easier for yourself by doing some thinking about your career right now.

If you're like most people in high school and haven't thought much about what you're going to do for a living some day, probably there are two or three things you'd like to know to help you decide. You'll want to know, for instance, what kind of work there is to choose from, and what jobs pay the best, and what kind of business to work for, and how to get the special training you'll need. Your guidance counselor can tell you more about this. And some of it we can tell you or help you with.

For instance, in the accompanying table you'll see the way the Census Bureau breaks down the different occupations; this will give you an idea of who does what these days.

This table tells us some interesting things. One thing it tells us is that a pretty big percentage of the people who work are working at things that

People Who Earn Salaries or Wages

	Thousands employed	Percent of total
Agriculture, Forestry & Fishery...	5,365	9.6
Mining..........	868	1.6
Construction......	4,062	7.3
Manufacturing....	15,735	27.8
Transportation, Communication, & Other Public Utilities.......	4,603	8.2
Wholesale & Retail Trades........	10,648	19.0
Finance, Insurance & Real Estate...	2,037	3.6
Business & Repair Services.......	1,274	2.3
Personal Services..	3,537	6.2
Professional & Related Services...	4,558	8.2
Public Administration...........	3,043	5.3
Entertainment & Recreation Services...........	486	0.9
Totals.......	56,216	100.0

need special training. Almost all of those in manufacturing need special training; all those in professional and related services need it; virtually all those in entertainment and recreation services need it; and most of those in public administration do, to mention just a few.

The Best Money

But let's look at it another way. Other Bureau of Census statistics tell who earns the best money. It's the doctors, lawyers, teachers, advertising people, engineers, chemists, metallurgists, executives, managers, specially trained clerical workers, sales people, skilled craftsmen, etc. And you can bet your bottom dollar that most of them have had special training—the higher the earnings, the more the training.

But money isn't everything. You'll find that you'll be happiest when you're doing something you like to do, something you're good at. And when people are good at something, they usually want to be as good as they can be at it. That means they take special training in it.

For instance, suppose you're a singer; you have a natural voice. You won't be happy until you train it so it's as good as you can make it. And that's the way it is with most natural aptitudes. There are some outstanding exceptions, of course, but the good ones usually work hard training themselves to be tops.

So, if you've gone along with us so far, we think you'll agree that it's smart to start thinking about your future career now, while you're in high school. For then you can start picking up what special training you can as soon as possible, in addition to your general subjects.

Career Training

Take the fellow who wants to be an engineer, for example. In order to make it easier for himself later, he'll make sure to get a good groundwork in math while he's in high school, for engineers just have to have math, no matter what kind of engineers they are—electrical, civil, mechanical, or something else.

Another example would be the fellow who wants to be a chemist. Maybe he wants to be a druggist, or a chemical engineer, or a research chemist. Whatever it is, he's going to need chemistry, and lots of it, so if he's smart he takes all the chemistry he can get in high school.

The fellow or girl who plans to be a teacher will want to make his or her plans early, too. Such plans would include more training in the basic three R's and social studies. Additional training would depend on whether the teacher is going to specialize in some particular subject or do grade-school work in all subjects.

We can't tell you in this short space all you need to do to prepare yourself properly for what you want to be when you go to work to earn

your living. Your guidance counselor can help you—and we'll try to give you some suggestions:

Try to learn a little more about the different businesses and industries in this country today. Find out what they do in the electrical business, in the automobile industry, or the food industry, or whatever sounds interesting to you. If you have any of those businesses near by, go and visit them; they usually are glad to have visitors. If they know you're thinking about working for them some day, they'll try to tell you more

about what they do and what kind of people they need.

Try, also, to find out just what people who work in the different occupations do—what an electrical engineer, a lawyer, a doctor, a chemist, a mechanical engineer, or people in other trades or professions do. Unfortunately, too many young people have the wrong idea about such things. They seem to think that an electrical engineer, for example, is a fellow who puts radios together or wires houses. People who do that are electricians, usually, although some electrical engineers do get into that kind of work.

Occupations Limited

Don't make the mistake of thinking that the occupation you prefer is limited to a small field of business. Electrical engineers, for instance, are needed not only by electrical manufacturers, but also by power companies, by industries like iron and steel and mining, by railroads, airlines, and many more. Big companies need people with all kinds of special training. The General Electric Company, for example, in addition to electrical engineers, needs mechanical engineers, metallurgists, chemists, physicists, lawyers, advertising men, and even doctors and dieticians, to mention just a few. About 45 per cent of the college graduates who come to work for us are not trained in engineering.

We hope we've convinced you that you should be thinking about your career now. Let your motto be: start getting trained early. And don't worry too much for fear that the training you get will be wasted later because you get into work that doesn't call for it. It's bound to come in handy.

INDUSTRY PROMOTES THE STUDY OF THE THREE R's (PART VII)

You may want extra copies of this article "Why Worry About a Career?" to help you guide the young people with whom you come in contact. They can be obtained free by writing to the GENERAL ELECTRIC REVIEW, Bldg. 2-107, General Electric Company, Schenectady 5, NY. In your request, please ask for publication PRD-110.

Electricity from Sunshine

(*Continued from page 29*)

the electrode reaction comprises about one thirtieth of the total direct cost of storage. Thus if structural members, electrolyte, and other components of the battery cost nothing and if the life remained the same, we could reduce the cost by at most a factor of 30.

Little hope exists of reducing costs still more by finding a cheaper electrochemical system than the present one using lead and sulfuric acid. Aluminum and magnesium are now the only metals that might permit a significant reduction in raw materials costs, but they fail to undergo reversible chemical reactions permitting energy to be recovered as electricity. Lower battery costs must come from improved design and manufacturing techniques or unconventional concepts, utilizing basic chemicals more efficiently and eliminating all superfluous materials.

The present cost of photovoltaic cells likewise exceeds the allowable cost for the proposed system. We may be able to reduce these costs by using polycrystalline material rather than single crystals and also materials permitting higher temperature operation. In addition, simplified manufacturing techniques for producing *p-n* junction photocells are urgently needed because 90 percent of the cost currently lies in processing.

A photovoltaic system for the conversion of solar energy to electricity thus appears technically possible. However, substantial reductions must be made in present prices of components—particularly the storage battery and the photovoltaic cell—to make solar electricity competitive with that now provided by fossil fuels and hydro power. We have good reason to believe this can be achieved.

Other Considerations

Meantime, the high cost is not incompatible with other applications. For example, a system of suitable reliability and compactness could find military applications and uses at unmanned installations at power-cost levels considerably above those of the home user. Also, in certain places the requirement for demand power might not be so stringent as in this country. If the need for prolonged electricity production at night were reduced, the storage system could be simpler and less expensive.

Why Solar Energy?

We see in the photovoltaic generation of solar energy one of several parallel paths toward solving the problem of future energy needs. While we will be faced relatively soon with a shortage of fossil fuels for generating electricity, fission energy will likely be able to carry a substantial portion of the electric-generating load in the not-too-distant future. Fission energy is produced in a form that will readily integrate with present power-distribution systems; central solar-generating plants are more difficult to envision.

Why then, you might ask, should we seriously consider solar-generated electricity at this time? Certain needs exist today for specialized electric power sources—needs that could be met in principle by solar energy. And exploration of any new area or application of science and technology usually yields important, unsuspected benefits. Ω

Devoting the talents of outstanding people. Staying ahead of potential aggressors requires quality of people as well as equipment.

How General Electric is trying to help meet the increasing challenges of defense

Today Americans are being forced to think in a totally new way about national defense. The United States can no longer expect to build military strength after an attack, but must be ready at all times to discourage aggression and maintain peace.

Yet, at the same time that a sizable portion of research, development, and production is constantly devoted to defense, we as a nation are striving to continue to advance our living levels.

Security with solvency

The resources of the nation are not limitless. Maintaining security with solvency presents a challenge to business and government to make sure that every citizen is getting the most for his defense dollar.

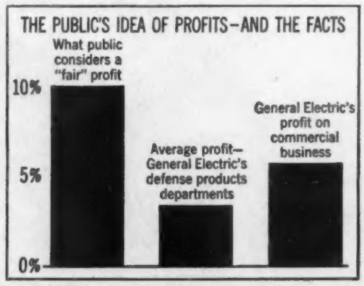
In helping meet this challenge, General Electric is:

- Devoting the talents of nearly half of the company's scientists, engineers, and technicians to defense activity.
- Bringing to bear its large-scale resources to pioneer vast and complicated defense projects . . . and then breaking down the big jobs into tasks to which thousands of other businesses contribute their specialized skills.
- Trying to conduct defense work as a business instead of an interruption of business.

Toward greater defense values

Meeting defense requirements is a continuing duty of responsible business. General Electric believes, however, that even fuller value from industry participation can be gained by infusing into defense work the same free-enterprise incentives that keep the civilian economy vigorous and able to supply good values to customers.

One way is to encourage maximum incentives for cost reduction in which both the taxpayer and the producer share in savings; another is to stimulate risk taking by making possible returns on defense accomplishments that warrant greater private investment.



As General Electric sees it, fully utilizing the incentives of a free society will deliver to every citizen greater defense value for his tax dollars . . . and at the same time continue to provide Americans with the highest living levels anywhere in the world.

Progress Is Our Most Important Product

GENERAL ELECTRIC

If you would like more information about General Electric's views and activities concerning national defense, please write us at Department A2-119, Schenectady, N. Y.

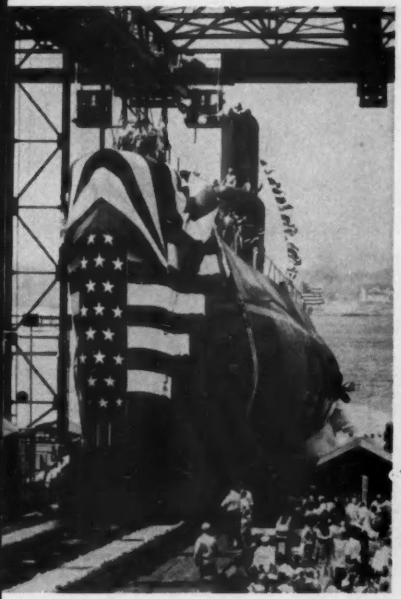

TECHNICAL WRITER—AIRBORNE ELECTRONIC SYSTEMS


APPLICATIONS ENGINEER—AIRCRAFT NUCLEAR PROPULSION


METALLURGIST—METALS AND CERAMICS RESEARCH


MECHANICAL ENGINEER—GAS TURBINE FOR HELICOPTERS

Nearly half of G.E.'s technical personnel is assigned to defense work, even though it is only about 20% of the company's total business.



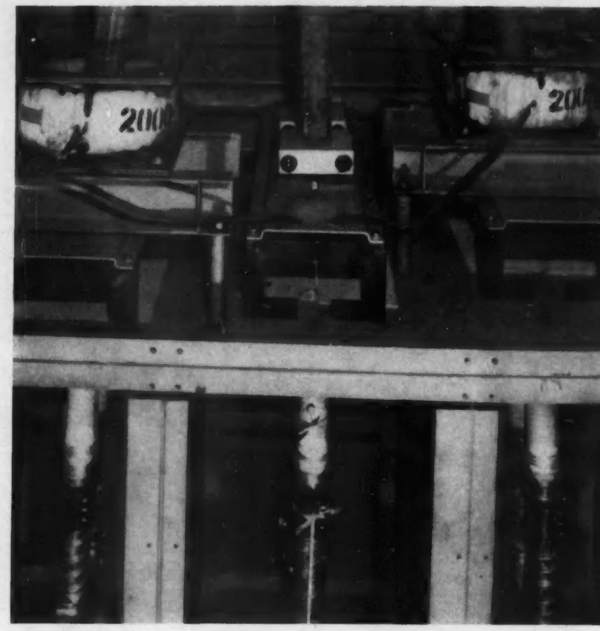
Bringing to bear large-scale resources. Typical of complex jobs undertaken by General Electric is development of atomic reactors for submarines (like the *Seawolf*, above).

Mobilizing the skills of businesses of all sizes. In taking responsibility for complicated defense projects, and breaking them down into jobs smaller firms can handle, General Electric brings together the specialized talents of many businesses. Here are a few representatives of more than 800 firms which help General Electric produce large radar units.

The revolutionary J79 jet engines powering the new B-58 supersonic bomber and F-104A fighter-interceptor were developed by General Electric. The J79 is the most powerful jet engine for its weight yet built.

Breaking the TEMPERATURE BOTTLENECK

The story of General Electric silicone-rubber cable



THESE G-E SILICONE-RUBBER GENERATOR LEADS are in use at the Washington Water Power Company's Cabinet Gorge generating plant.

Several years ago, electrical engineers faced a virtual bottleneck in the use of high-temperature equipment. They had already obtained greater equipment capacity and reliability through the development and rapid adoption of Class H insulation for generators, transformers, motors, and switchgear.

But, in many cases, this capacity could not be fully utilized, and the reliability was partially negated, by the cables then available. These cables had a maximum permissible copper temperature of 70 to 85 C—could neither carry the load nor withstand the temperatures of the equipment to which they were connected.

Temporary solutions were developed, such as locating copper connections on transformers and switchgear away from heat, and stripping motor cable connections of their regular insulation and rewinding with hand-applied Class H insulation.

DEVELOPING NEW INSULATIONS

But G-E engineers continued their search for *new* insulations. Asbestos and glass had excellent high-temperature qualities, but their low dielectric strength was a drawback — especially in applications above 600 volts.

Then General Electric engineers tested silicone rubber. Silicone rubber glass tapes possessed excellent qualities and could be applied to cable by the same economical methods as conventional tapes of varnished cambric.

The result? A new cable insulated with silicone-rubber-coated glass cloth for high-temperature generator leads. (See Fig. 1.) New silicone-rubber cables with extruded insulation were also developed for power and control circuits.

These cables are rated at 125 C conductor temperature for service up to 15 kv for tape types and 5 kv for extruded types. They are proving especially valuable to plants where thermal bottlenecks prevent full use of equipment or where space is limited.

ECONOMIC CONSIDERATIONS

Silicone-rubber cables offer many economic advantages (See Fig. 2 below). They can be installed in existing ducts and conduits, thereby reducing first costs. They require less space on new jobs—and future expansion need not involve extensive renovation.

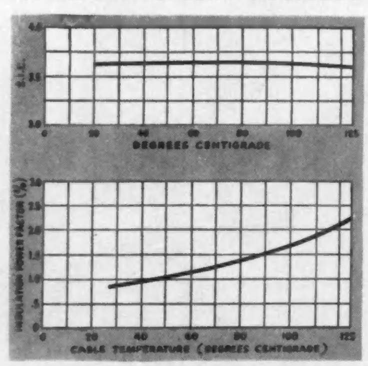


Fig. 1: DIELECTRIC PROPERTIES OF SILICONE-RUBBER GENERATOR CABLE—Typical test results obtained on a single-conductor, 2500 MCM, 15 kv cable, insulated with 0.25" of silicone-rubber-coated glass tapes.

Furthermore, silicone-rubber cables increase the reliability of your entire electrical system because the weak link of low-temperature cables has been removed. The recurrent expense of replacing burned-out cable is minimized.

FREE BOOKLET OFFERED

You can obtain complete information on the new silicone-rubber cables by writing for the booklet, "Silicone-rubber Wire and Cable" to Section W204-937, Wire and Cable Department, General Electric Company, Bridgeport 2, Connecticut.

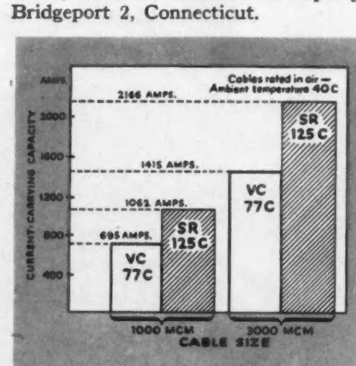
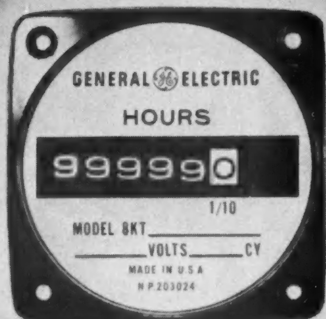


Fig. 2: COMPARISON OF CURRENT-CARRYING RATINGS — Varnished cambric vs silicone rubber cable. Based on 9 cables in duct bank, 100% load factor, 25 C earth, open-circuit sheath.

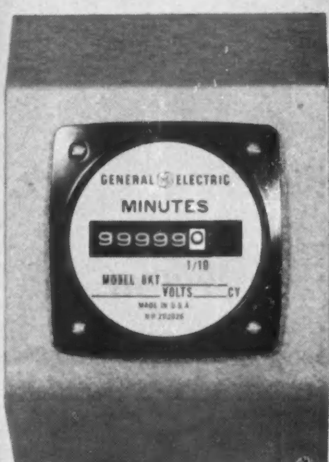
Progress Is Our Most Important Product

GENERAL ELECTRIC

Round model for panel mounting.



Square model for panel mounting.



Portable model for laboratories.

Conduit case for easy installation.

NEW General Electric Time Meters cost less, read easier, give wider range of measurement

ALL DIGITS 2½ TIMES LARGER—NEW, EXTRA DIGIT GIVES WIDER RANGE FROM 0 TO 99999.9 HOURS OR MINUTES

OLD
(Life Size)

NEW
(Life Size)

At a new, low cost, General Electric now offers you a complete line of time meters for measuring operating time of every type of electrical equipment.

Available in 2½ and 3½ inch sizes these new General Electric Time Meters offer you these important benefits:

- **DUST-PROOF PROTECTION** . . . due to totally enclosed construction. Sealed models also available to military specifications.
- **RESET MODEL** . . . conveniently located reset knob available (optional) on all General Electric Time Meters except sealed models.
- **INCREASED OPERATING TEMPERATURE RANGE FROM** —67F to 150F . . . means more flexible application and longer meter life.

3 WAYS YOU BENEFIT WITH GENERAL ELECTRIC TIME METERS:

LOWER COST, BETTER PLANNED MAINTENANCE . . . because you can measure the operating time of your equipment, thus allowing you to apply pre-planned productive maintenance.

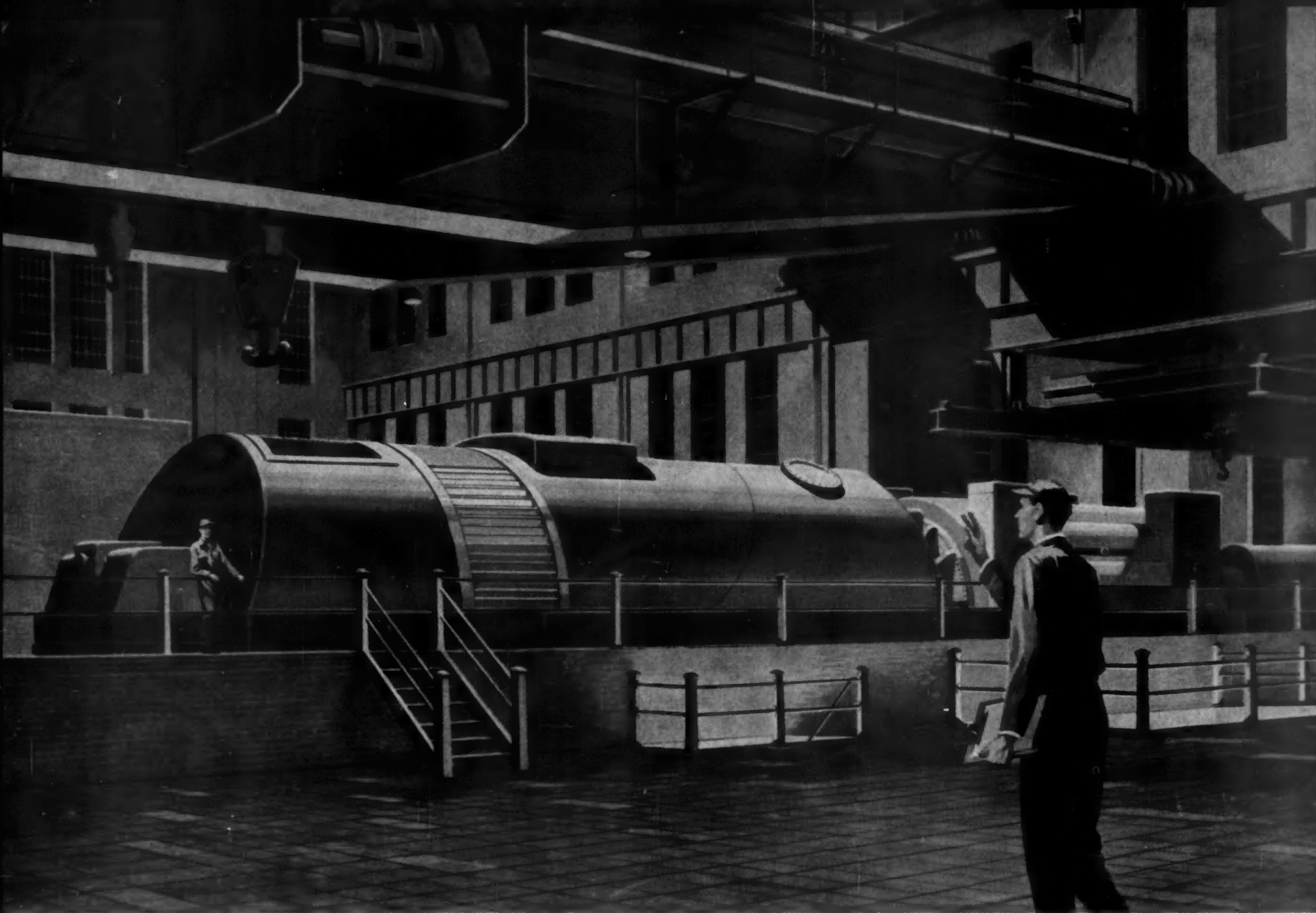
LESS DOWNTIME, FEWER PRODUCTION LOSSES . . . because you can measure the total operating life of your equipment, and thus replace it on a scheduled basis before it breaks down unexpectedly.

BETTER UTILIZATION OF MANPOWER AND MACHINES . . . because General Electric Time Meters measure the shutdown time of your equipment, allowing efficient scheduling of employee and machine work assignments.

FOR AN ACTUAL DEMONSTRATION of how these new General Electric Time Meters can help you save money and improve operating performance, call your nearest General Electric Apparatus Sales Office. And write today for descriptive bulletin GEA-6710, General Electric Company, Section 584-12, Schenectady, N. Y.

Progress Is Our Most Important Product

GENERAL ELECTRIC



NEW STEAM TURBINE AT PHILO PLANT POINTS WAY TO INCREASES OF UP TO FIVE PER CENT IN STEAM PLANT THERMAL EFFICIENCIES.

Supercritical, double-reheat steam turbine introduces new design concepts

Thermal studies have revealed significant potential fuel savings from the use of supercritical pressures and higher temperatures. Today's challenge—how to take advantage of this potential efficiency.

GENERAL ELECTRIC ENGINEERS took the first major step toward economical use of these higher steam conditions when they designed and built the world's first supercritical-pressure, double-reheat steam turbine for the Philo Plant of the Ohio Power Company. This turbine, rated 125,000 kw, operates with initial steam conditions of 4500 psig and 1150 F, with 1050 F first reheat and 1000 F second reheat temperatures. These advanced steam conditions, coupled with the first application of the double-reheat cycle, can increase thermal efficiency five per cent over the most efficient steam plant now in operation.

One of the major problems General Electric designers had to overcome was the susceptibility to thermal distortion of thick austenitic castings and forgings. So the amount of austenitic steel used was held to a minimum by the application of new design concepts such as steam cooling, small individual control and stop valve bodies, and simplified throttling control with full 360-degree arc admission to the first-stage nozzles.

THE EXPERIENCE GAINED from designing and building this unique machine is already being applied to larger unit designs to get greater advantage from higher temperatures and pressures. For more details on the Philo unit write for bulletin GER-1130, Large Steam Turbine-Generator Department, General Electric Company, Schenectady 5, New York. 254-58

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