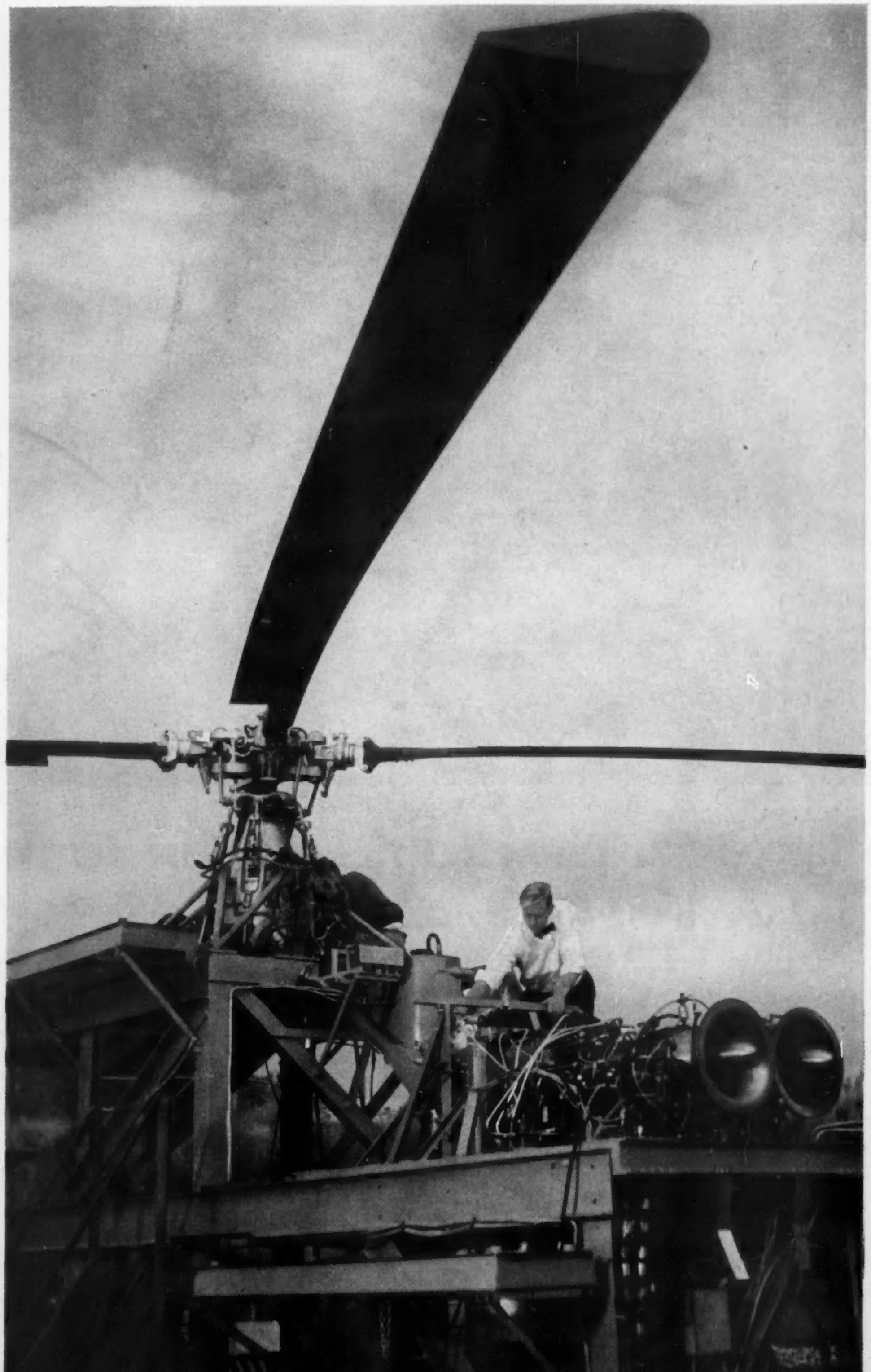
GENERAL ELECTRIC Review

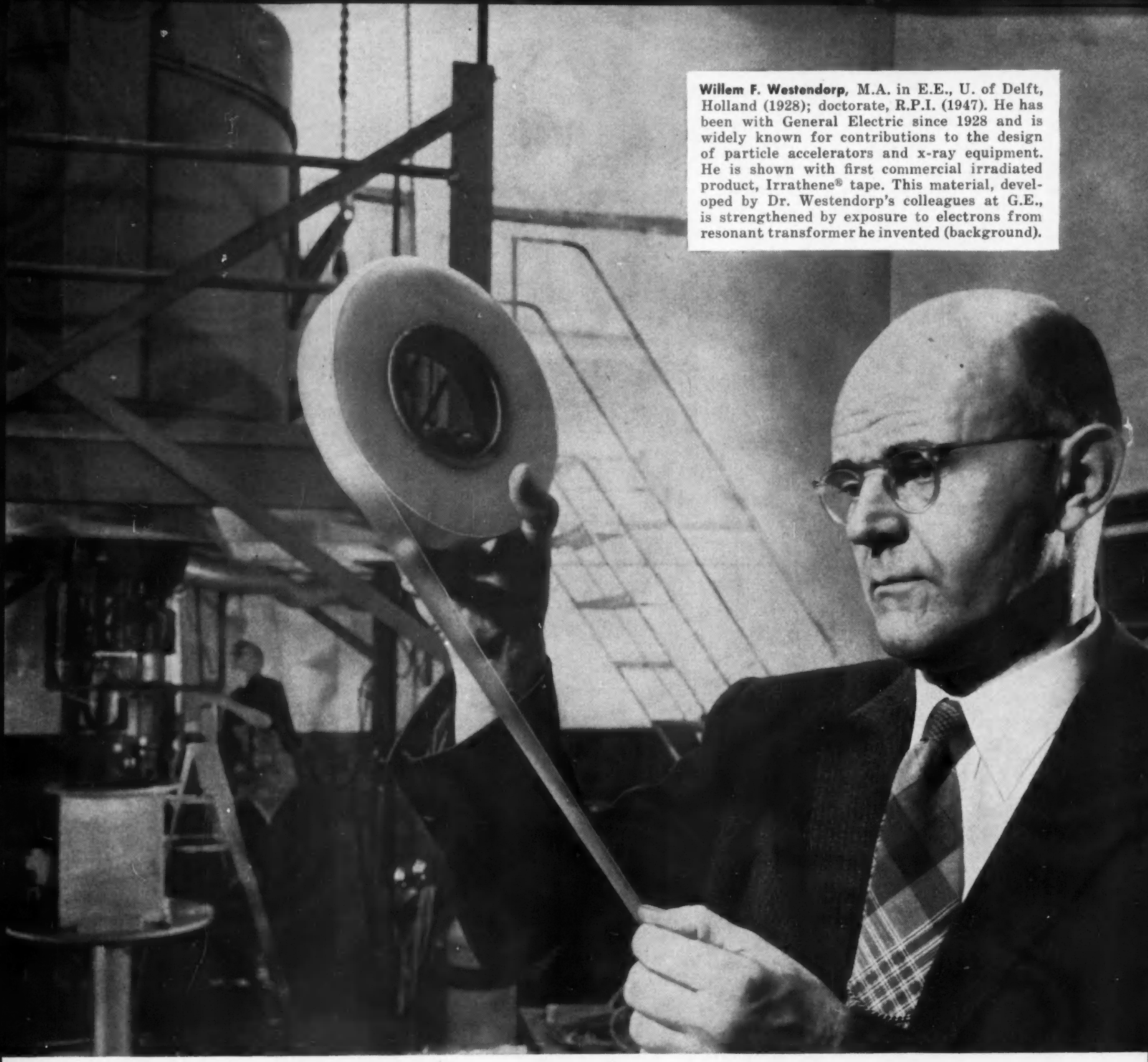
MAY 1957



IN THIS ISSUE

- Scientists—Prophets?
- Hospital Lighting
- Thermal Thicket
- Industry's Thirst
- Toaster Comes of Age

Turboshaft engines for helicopter on test—recent development in gas-turbine's unique history (page 8).



Willem F. Westendorp, M.A. in E.E., U. of Delft, Holland (1928); doctorate, R.P.I. (1947). He has been with General Electric since 1928 and is widely known for contributions to the design of particle accelerators and x-ray equipment. He is shown with first commercial irradiated product, Irrathene® tape. This material, developed by Dr. Westendorp's colleagues at G.E., is strengthened by exposure to electrons from resonant transformer he invented (background).

High voltage for medicine and industry

Studies in electron physics by Dr. W. F. Westendorp of General Electric led to the versatile resonant transformer

When a child on a swing wants to "go higher," the easiest way for father to impart needed energy is through a series of gentle, properly timed pushes. Dr. Willem F. Westendorp of the General Electric Research Laboratory used a similar idea in creating the *resonant transformer*, a machine that increases voltages from 200 to as high as 4,000,000 in a series of low-frequency "pushes" from carefully tuned coils.

In x-ray equipment, the resonant transformer is being used extensively for cancer therapy. In industry, it makes possible the inspection of steel up to eight inches thick.

As the modern scientist's cheapest and safest source of high-voltage electrons, this transformer has been used recently in such fields of research as atomic energy and food and drug sterilization. It is also the key tool in the new area of "radiation chemistry."

Dr. Westendorp's work is but one example of how scientists at General Electric are uncovering new knowledge that can contribute to better living standards for people today and for generations to come.

Progress Is Our Most Important Product

GENERAL ELECTRIC

GENERAL ELECTRIC
Review

MAY 1957 VOLUME 60 NUMBER 3

EDITOR
PAUL R. HEINMILLER

RESEARCH AND ENGINEERING EDITORS
JOHN J. RAFFONE
GORDON W. NUGENT

COPY AND OPERATIONS EDITOR
ALICE S. ALLEN

EDITORIAL ADVISORY COUNCIL
CHARLES A. CHURCH
DR. MILES J. MARTIN
F. MORLEY ROBERTS

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 U.S.A. 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 Publisher. . . . The contents of the GENERAL ELECTRIC REVIEW are analyzed and indexed by the Industrial Arts Index, The Engineering Index, and Science Abstracts. . . . 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. . . . Address all communications to Editor, GENERAL ELECTRIC REVIEW, Schenectady 5, NY.

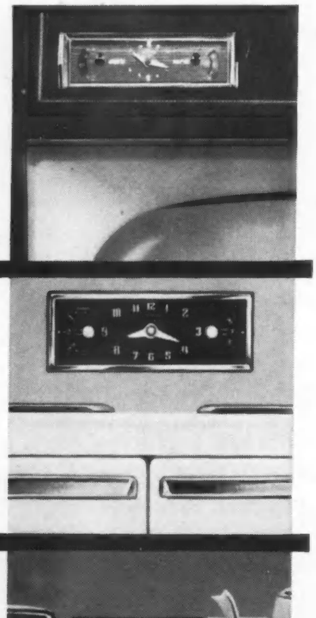
COVER

Two T58 turboshaft engines, developed for the Navy by General Electric's Small Aircraft Engine Department; each weighs 325 pounds and individually develops more than 1000 hp. Utilizing the free turbine principle, they employ a unique constant-speed control. The engines' special test rig for a Sikorsky S58 rotor system simulates true loading of the helicopter. See article on page 8 for the history of gas-turbine development here and abroad.

new

LONG . . . LOW . . . LUXURY-LOOK

custom-styled, competitively priced, all-purpose timer



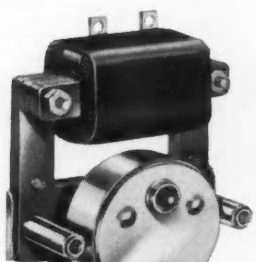
For TV sets

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.



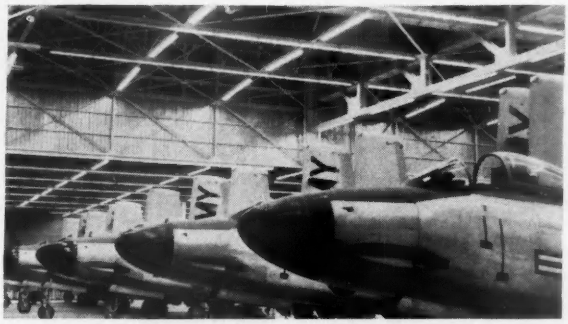
TELECHRON

MARK OF TIMING LEADERSHIP

Companies using General Electric's Simplified Lamp Replacement Plan save as much as $7,500 a year!

E. A. Linsday, well-known G-E authority on industrial lighting.

SPECIAL REPORT by E. A. Linsday



FACTORIES, like McDonnell Aircraft Corp., realize big savings annually with General Electric's Simplified Lamp Replacement Plan. They maintain a higher light level, too.

OFFICE BUILDINGS are kept brighter—at lower cost. Brown Shoe Company uses this new relamping system in their new St. Louis office—saving about 10¢ per lamp per year!

SMALL BUSINESSES can profit, too, by replacing all their lamps at one time. Naturally, the dollar savings will not be as important as the savings in time and trouble

CLEVELAND, OHIO—Ask anyone here at General Electric why they're so enthusiastic about the G-E Simplified Lamp Replacement Plan—replacing fluorescent lamps in groups instead of one-at-a-time—and he'll explain it this way: "If you knew exactly when your car was on the brink of costing you a big repair bill, you'd stop driving it just short of that point and trade it in, wouldn't you? Well, we control the making of our lamps so carefully that we are able to tell you the most economical time to change them. This enables our customers to replace *all* the G-E Lamps in a given section or department before the great majority are about to burn out." The result? Fewer interruptions of office or factory work; a cleaner, brighter lighting system; fewer starter and ballast breakdowns; more light for the money.

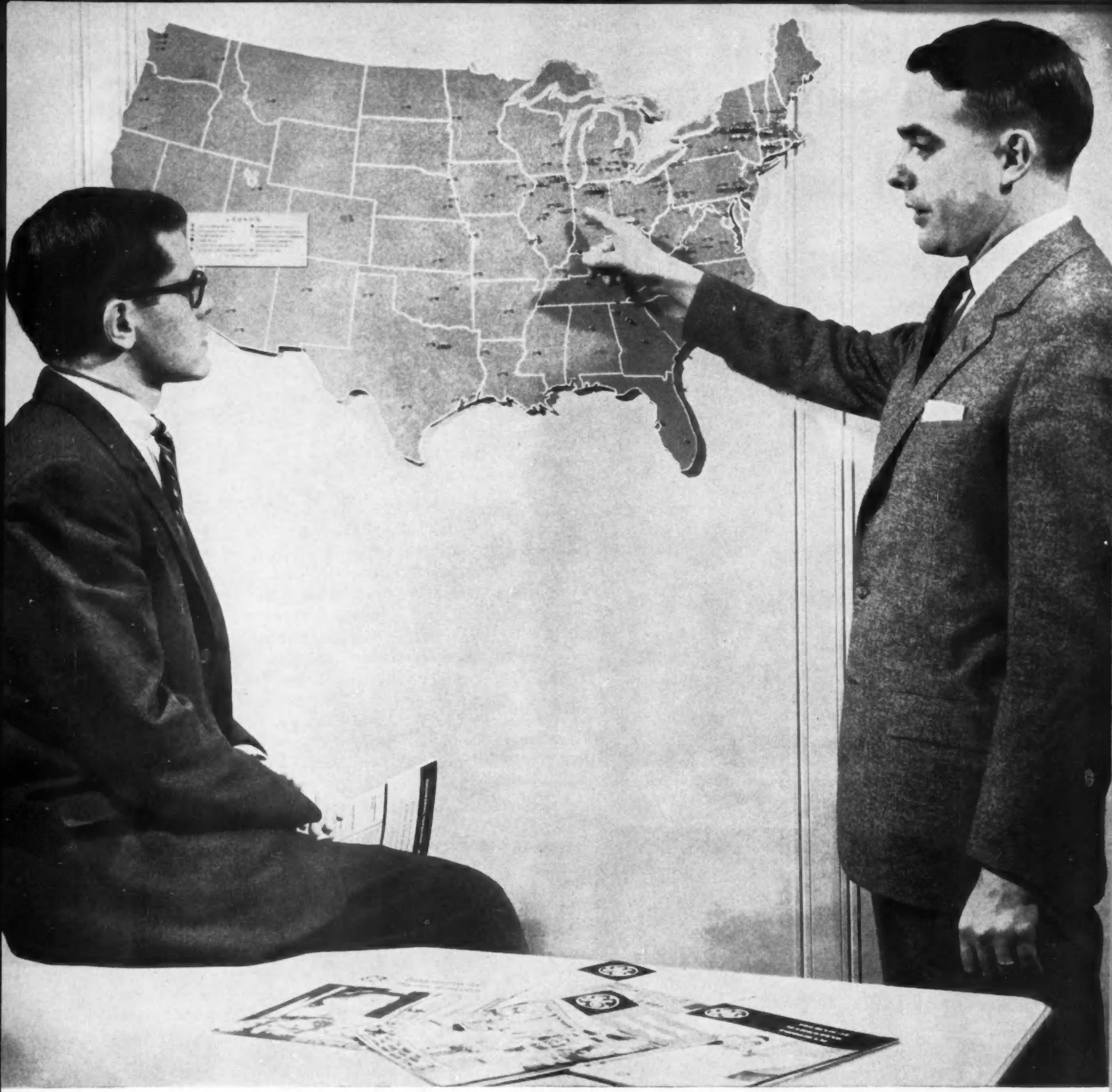
30 LAMPS OR 30,000—Regardless of its size, your company can benefit by General Electric's Simplified Replacement Plan. Brown Shoe Company does this in their beautiful new St. Louis offices. By changing their 5,000 lamps every 18 months, they save about $500 a year. At McDonnell Aircraft, they replace over 30,000 G-E Lamps regularly with a reported yearly savings of $7,500! On the other hand, the owner of a filling station in Burlington, Vermont, replaces his few lamps yearly and he saves, too. Naturally his dollar savings are of secondary importance to his savings in time and annoyance.

LET G-E's GROUP RELAMPING PLAN CUT YOUR COSTS. Since one-at-a-time lamp replacement adds up to a big expense, it's easy to make substantial savings by taking advantage of the *uniform performance* of G-E lamps. Early burnouts are avoided. Actual results show that 99 out of 100 General Electric fluorescent lamps will still be burning after a year's service in single-shift plants.

GET THE WHOLE STORY on G-E's Simplified Lamp Replacement Plan. Write for the booklet, "Group Relamping Pays Dividends"—General Electric Company, Large Lamp Dept. GE-5, Nela Park, Cleveland 12, Ohio.

Progress Is Our Most Important Product

GENERAL ELECTRIC



GENERAL ELECTRIC OFFERS . . .

Engineering opportunities in 150 U.S. cities

The geographic location in which you will work and live is one important consideration as you plan your future career. There are many reasons why technical graduates join General Electric Company. One of these is the opportunity to work in engineering, marketing, and manufacturing in any of 150 American cities in 45 states.

Thus, an engineer can satisfy his geographical preferences in planning both his professional career and selecting his future home.

General Electric's continuing expansion in over 200,000 product lines has been highlighted by this wide dispersal of Company facilities. Boundless opportunities in engineering, manufacturing, and marketing are open to outstanding engineering and science graduates in a variety of professional interests. You can find the satisfaction of a highly rewarding career with one of the nation's most diversified enterprises.

For more information about General Electric's programs for technical graduates, consult your Placement Director or write to Mr. Gregory Ellis, General Electric Company, Section 959-2, Schenectady, N. Y.

Progress Is Our Most Important Product

GENERAL ELECTRIC

ERASE THE QUESTION MARK

Who determines the *professional* status of a group: the group itself? society? or the members of a profession?

Let's look at professionalism as it applies to groups and see if we can come up with a few answers.

In my office recently, I tried an experiment with five men: two engineers, an educator, an art director, and an audio-visual communications specialist. To trigger some ideas, I asked them to name some professions at random—not in any particular order but just as they came to mind. If one of the men thought a profession named was marginal, we put a question mark after the word.

When we had finished, the list—written on a large wall pad—looked like this:

MEDICINE
LAW
THEOLOGY
EDUCATION
POLITICS (?)
ENGINEERING, SCIENCE (?)
EDITING, WRITING (?)
ART
ARCHITECTURE
ENTERTAINMENT
ADVERTISING AND PUBLIC RELATIONS
FINANCE
SPORTS
MILITARY

Of course these don't exhaust all the possibilities. Pressed for time, we couldn't develop the list completely. But as you can see, it's fairly representative. You might want to carry this experiment further by discussing it in your car pool or at an informal gathering with friends.

We quickly moved on to the next step: Finding the criteria—the common denominator—for judging universal professionalism.

This time our wall pad read:

LEGAL STATUS
SERVICE TO MANKIND (Dedication)
PREPARATION AND CONTINUING SEARCH
EDUCATION (Formal and nonformal)
CREATIVE APPROACH TO PROBLEM SOLVING
ACCEPTANCE BY SOCIETY, ASSOCIATES

Our "panel of experts" warmly contested each item. But they agreed that *Legal Status* applies to only certain groups and that *Education* must be considered in its broadest connotation.

Preparation and Continuing Search and *Creative Approach to Problem Solving* didn't receive their unqualified approval. For a gray area exists in certain trades and skills—those not usually classified by society as a profession. The five experts recognized that *degree* of creative approach might be a factor. But the question remained, how much?

Even *Service to Mankind* stood on shaky ground. "A professional night-club entertainer, a professional baseball player, and some writers may be dedicated, but their services to mankind are a tenuous thing," commented the communications specialist.

Acceptance by Society and Associates—basic to the problem, the panel agreed—struck common ground as the determining factor in a group's professional status. However, society's fuzzy and sometimes superficial definition of a professional group may not necessarily agree with the criteria established by professional groups themselves. This creates a double standard: the man-in-the-street professional and the professional's professional.

Wouldn't it be futile then to attempt to sell the man in the street the professional's definition? Could he be influenced one way or the other? Probably he doesn't care. Nor will limiting definitions established by a professional group prevent other vocations from assuming the title of professional in the eyes of the public.

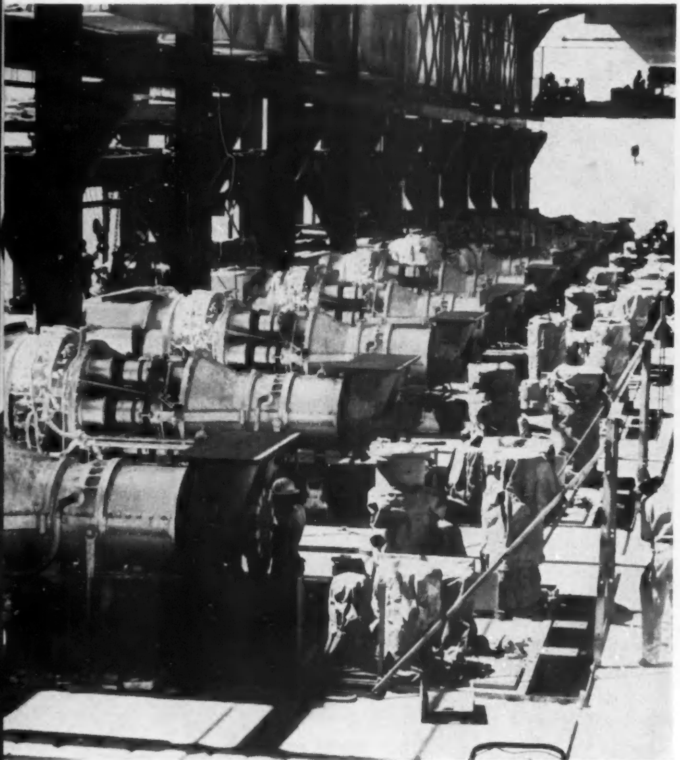
With these factors in mind, it seems that the words and sounds being generated in some circles today about professionalism are a bit pointless. Action is the real answer. Action: doing the kind of thing that will cause society to recognize and respect a specific profession or, more important, the individuals in that profession.

If engineers will adhere to this, people will no longer question the validity of engineering as a profession.

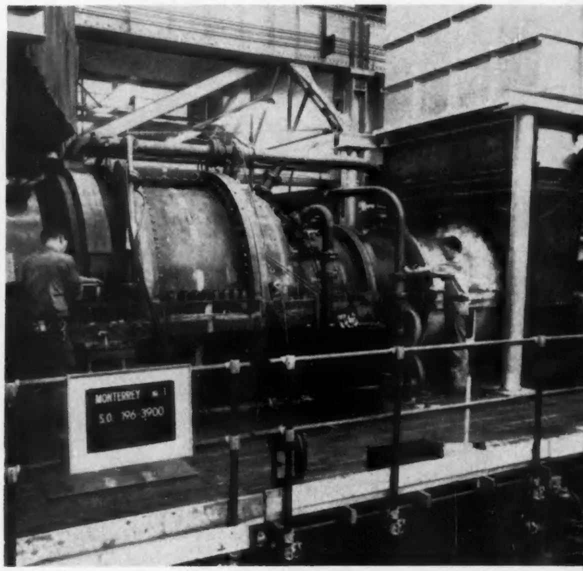
By maintaining a high standard of professional behavior and by becoming a better engineer, the individual can contribute much more to mankind, himself, and his profession. . . .

. . . and help erase the question mark.

Paul R. Heinmiller
EDITOR



Compression Concentrated group of gas turbines pressurizes the oil fields located beneath Lake Maracaibo, Venezuela.



Power Largest capacity gas turbines in Western Hemisphere, rated 16,000 kw, will supply electric power to industries in Monterrey, Mexico.

Bridging the Gap in

America hesitated in buildin design in this critical perio

By DR. C. W. SMITH

On November 30, 1791, shortly after the close of the American Revolution, the British Patent Office issued patent No. 1833 to John Barber. This patent described a gas-turbine power plant that included in elementary form all the principal components of the modern plant. Yet until about 1940, few engineers took this type of power plant seriously—the average person still thinks of it as a modern invention.

After this long period of quiescence, however, the gas turbine—like a delayed-action bomb—made its presence felt with explosive effect by revolutionizing the aircraft industry.

You may reasonably ask: Why this long delay? and why did active development of the gas turbine as an aircraft power plant start in Europe rather than in the United States? The answers to these questions contain more than academic interest.

Hindsight doesn't necessarily result in future foresight. But a brief historical review may reveal to you whether any significant acceleration could have been possible, and whether the delay can be attributed in any degree to practices or habits of thought that American engineers can guard against in the future.

Forerunners of the Gas Turbine

A stationary gas turbine and a conventional turbojet engine, though essentially the same (illustration), differ somewhat. In a stationary plant, the intake diffusion and the expansion through the propulsion nozzle would be lacking, and the shaft load would be something other than a propeller.

The principle of the turbine itself dates back to antiquity. And although it's apparent from Barber's patent that the principle of the gas-turbine power plant was understood from at least the beginning of the 19th century, neither steam nor gas turbines were built during most of that century. Instead, the reciprocating steam engine was developed early and remained for many years the dominant type of power plant. Probably the high operating speeds required for large turbine outputs and high efficiencies were excessive for the materials and bearings of the day. Nor was theory, especially as it pertained to turbine nozzles, adequate to provide a good foundation for practical design.

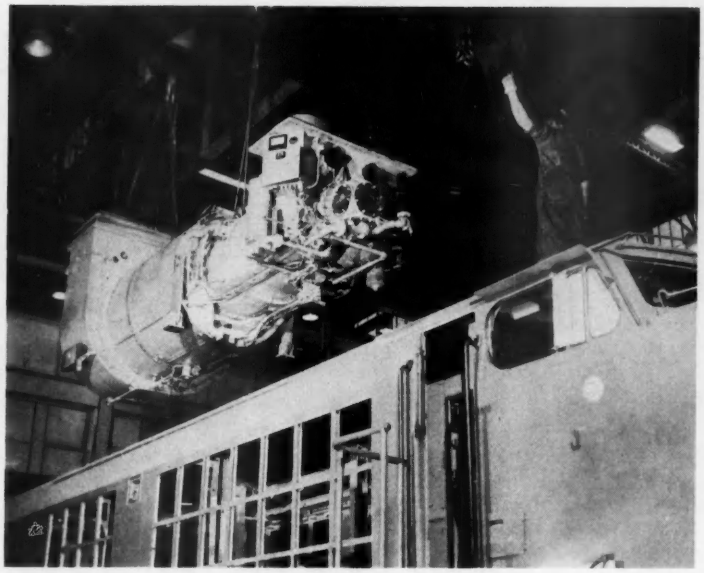
Toward the end of the 19th century, however, the steam turbine was perfected; and in a few years it had almost completely superseded the reciprocating steam engine. You might logically expect parallel development of the gas turbine. On the contrary, almost contemporaneously with the perfection of the steam turbine, development of the reciprocating gas engine began. And many years passed before attention turned to the gas turbine.

Why the Reciprocating Engine?

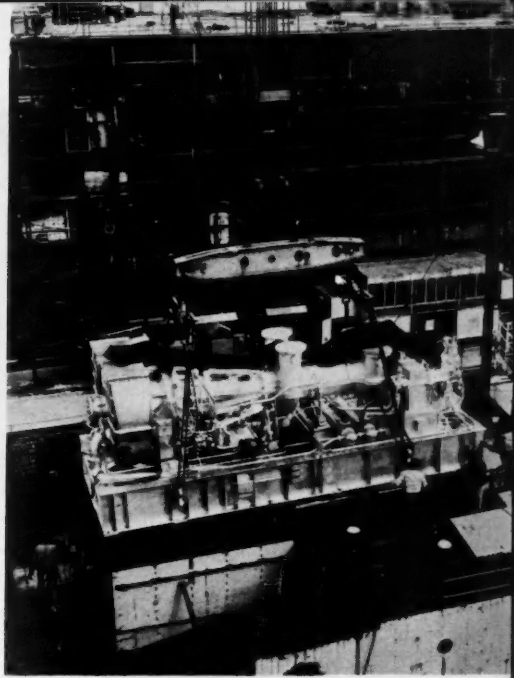
You may still raise the question as to why industry could proceed with the reciprocating gas engine.

Temperatures in a reciprocating en-

Dr. Smith—at present with the Engineering Section, Small Aircraft Engine Department, Aircraft Gas Turbine Division, Lynn, Mass.—came with General Electric in 1922. Author of the book *Aircraft Gas Turbines*, published in 1956 by John Wiley & Sons, his work with the Company has been chiefly in research, development, and design of superchargers, air compressors, and steam and gas turbines.



Rail Powered by this 4500-hp unit, 25 gas-turbine-electric locomotives haul approximately 10 percent of all freight on the Union Pacific Railroad; new 8500-hp units will be delivered in July.



Marine Modified land gas turbine propels converted Liberty ship *John Sergeant* at 18.046 knots.

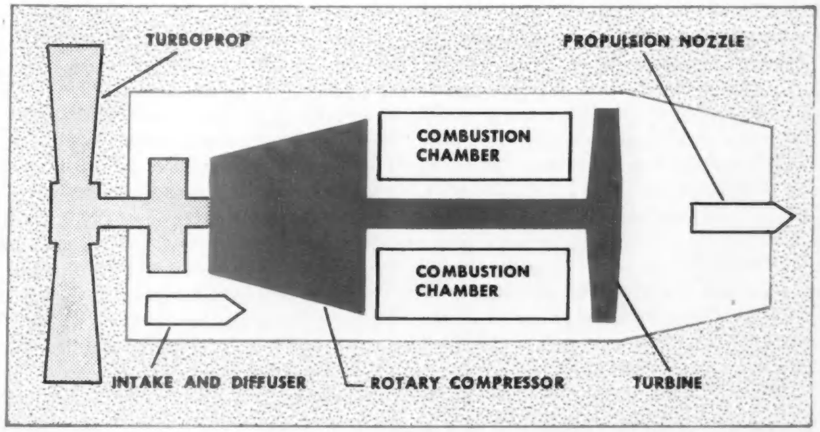
the Gas Turbine's History

as turbines during the years preceeding World War II; yet European noved ahead, given impetus by military urgency.

gine are high just after ignition. But the high-temperature region is concentrated, and temperature reduces rapidly as the gas expands to do work on the piston. Moreover, the stresses result chiefly from the pressure inside the cylinder. You can reduce them to any reasonable value by adding more metal. In the gas turbine, on the other hand, the stresses are of the centrifugal type. They can't be reduced below a certain minimum value regardless of the amount of metal added.

Even more important to a reciprocating gas engine, the cylinder walls and valves are washed periodically by a fresh cool charge, keeping the metal temperature much lower than the maximum gas temperature. Contrariwise, hot gases flow steadily through a gas turbine, with little or no opportunity for cooling.

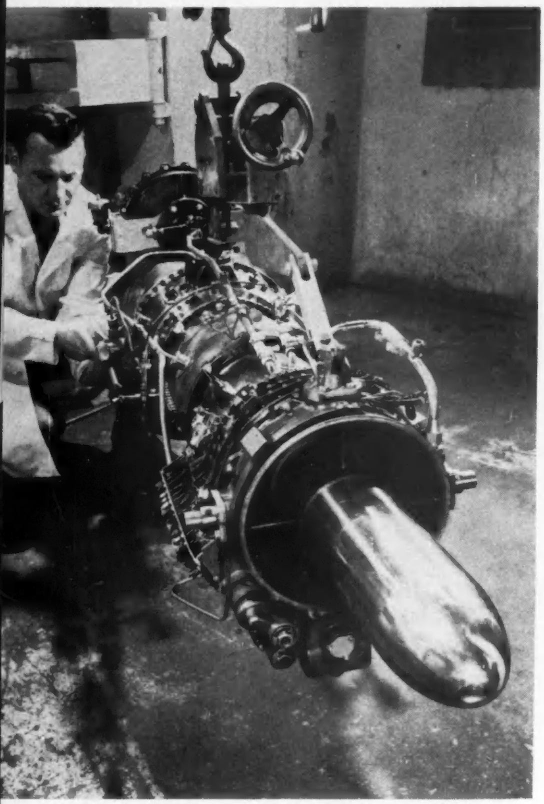
The maximum permissible gas temperature in the reciprocating engine is much greater than in the turbine, thus requiring less diluent air. In the reciprocating engine the ratio of air flow to fuel flow may be almost stoichiometric—that is, chemically correct—as contrasted with a ratio perhaps three or four times as great in the turbine. The less the excess air, the less the loss of availability of heat released by the combustion, and the greater the over-all efficiency.

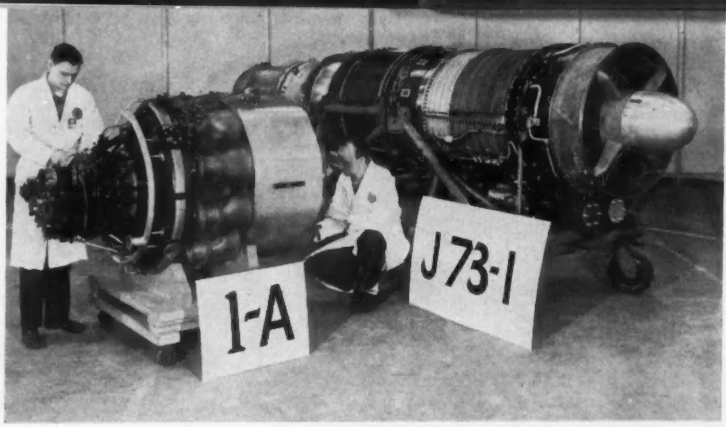


Aviation Operation of turboprop or turbojet engine is similar to stationary gas turbine. But except for turbosuperchargers (next page), America constrained interest in aircraft potential until World War II.

If cylinders provide sufficient capacity, possibly more efficient compression can be accomplished in a reciprocating compressor rather than in a rotary type.

In a reciprocating engine the piston acts directly on the air to decrease its volume and increase its pressure, theoretically without imparting any appreciable velocity. In a rotary compressor the energy imparted to the air is origin-





Milestones in Aviation

Dr. Sanford A. Moss (glasses) in 1946 pointed out turbosupercharger features to Gen. James A. Doolittle. A significant achievement, the turbosupercharger proved an invaluable background in constructing the first American-built jet engine, the I-A. One recent development in aircraft gas turbines is the small T58 turboshaft (engine left) that has a remarkably high power-to-weight ratio.

ally in the kinetic form and can be converted into static pressure head only by means of subsequent diffusion—a relatively inefficient process. Similarly, a turbine first produces kinetic energy and then converts this to shaft work. Although you must also consider other factors, this intermediate production of kinetic energy has an adverse influence on the efficiency of a rotary versus a reciprocating machine.

Power Plants

Development of rotary compressors—both of the centrifugal, or radial-flow, and axial-flow types—dates from about the beginning of the present century.

Because of its greater ease of manufacture and correspondingly decreased cost, the centrifugal type progressed much more rapidly than axial-flow compressors. From 1910 onward a large number of centrifugal compressors were built for blast-furnace and other industrial applications. During the closing days of World War I, the centrifugal compressor was selected for the turbosupercharger—the immediate predecessor of the aircraft gas-turbine power plant. Meanwhile, although Sir Charles Algernon Parsons had built a few axial-flow compressors in the 1900 to 1910 period, for many years development of this type proceeded slowly.

Engineers' interest in the independent gas-turbine power plant didn't lag while the steam turbine and the reciprocating gas engine were in process of development. Though we could name a number of investigators who were active in gas-turbine research previous to and just after 1900 and though their work constituted a necessary foundation for later development, no practical power plants were produced. Charles Lemale and René Armengaud in France, Norman Davey in England, and Dr. Sanford A. Moss in the United States are representative of the workers in the field at that time. About the beginning of the century, Hans Holzwarth began a long career devoted almost exclusively to the constant-volume, or explosion, gas turbine. This type has met with far less favor than the constant-pressure type, although the compound aircraft engine operates on essentially the same cycle.

Several different ground power plants built or begun during the 1930's helped to pave the way for the aircraft gas turbine. Among them were two of Holzwarth's design, manufactured by Brown Boveri Limited, the first of which operated successfully for short periods as early as 1933 and completed a nearly continuous run of 470 hours in September 1937. The August Thyssen Steel Works of Hamborn, Germany, then ordered a second unit of 5000-kw capacity, installed in 1940. Successful operation of the second unit, probably the first large industrial gas turbine in actual service, was reported but details aren't available.

Beginning about 1931, Brown Boveri developed a boiler, in reality a supercharged steam generator. In it, the hot products of combustion are forced around the water tubes at high pressure and high velocity to increase the rate of heat transmission. A gas turbine operated by the waste gases from the boiler furnishes the power for compression. Although not strictly an independent power plant, it provided a powerful stimulus to further development, especially of axial-flow compressors.

The Houdry cracking process for producing gasoline, in which a certain operation is carried out with gas at high pressure and temperature, furnished another stimulus. For the gas expanded in a turbine to deliver sufficient shaft power to drive an electric generator as well as the necessary compressor. These turbines, first developed by Brown Boveri, have been manufactured in this country by Allis-Chalmers and operated for long periods at the Marcus Hook refinery of the Sun Oil Company.

Among the other gas turbines of the 1930's was a constant-pressure unit of George Jendrassik's design built at Budapest, Hungary, in 1935, with assistance from the Hungarian government. Also, a constant-pressure stand-by plant for a bombproof shelter was built by Brown Boveri for the city of Neuchatel, Switzerland, in 1939.

The Jendrassik unit, which included an axial-flow compressor and heat regenerator, developed about 100-hp net output at 16,400 rpm with a thermal efficiency of 21.2 percent. The Neuchatel unit of 4000-kw capacity used no cooling water and required as an auxiliary only a small diesel-driven alternator to supply the starting motor in the event of a complete power failure. (Its efficiency was reported to be about 17 percent, although it had no heat regenerator.) In 1939, Brown Boveri also began designing a gas-turbine locomotive that from 1942 onward operated successfully for long periods on nonelectrified railway lines of the Swiss Federal Railway.

Aircraft Gas Turbine—Neglected

With the suitability of the gas turbine for aircraft power plants well established, let's inquire into its apparent neglect during the 1930's.

Actually, much interest in the theoretical possibilities of the aircraft gas turbine was shown at this time, especially by the United States Army Air Force. Except for the continued development of the turbosupercharger, however, this interest was not translated into actual construction of units in the United States.

Nor did the idea receive enthusiastic acceptance in England. Despite this, Sir Frank Whittle, who had become interested in the aircraft gas turbine even before 1930, obtained financial backing and formed a company known as Power Jets, Ltd. Because this company lacked manufacturing facilities, the first units were actually built chiefly by the British Thomson-Houston Company. By 1938 a power plant operated successfully on a bench test, and a redesigned unit installed in a Gloster airplane made the first English flight in May of 1941.

Almost simultaneous with the development in England, programs involving actual construction were proceeding in Germany and Italy.

So far as is known, the first flight of a jet-propelled airplane occurred in Germany in 1939. To permit concentration on conventional power plants, the Germans curtailed further development for a time. But when it became apparent that the war would be prolonged, they again accelerated development of the aircraft gas turbine. As a result, at the war's end, Germany was much further advanced than her adversaries, having turbojets in fairly high production. Flight tests of an Italian power plant—an unusual type developed by Campini—were made in 1940 and 1941. The war prevented further development.

England was militarily hard-pressed in 1941. Accordingly, the British Ministry of Aircraft Production invited the U.S. Army Air Force to cooperate in further development and manufacture of the Whittle unit.

In September 1941, the Air Force asked General Electric to undertake development of the aircraft gas turbine in the United States and asked Bell Aircraft to design a suitable airplane. Within six months of the time work began, General Electric completed its first unit. And the first jet engine flight in the United States occurred at Rogers Dry Lake (formerly Muroc), California, in October 1942.

The lag in the United States as compared with European countries during the 1930's is sometimes ascribed to the lack of high-temperature-resistant materials and compressors of sufficiently high efficiency—though hardly a valid explanation. For even in the early 1930's, sufficiently good materials were available. (Some of these were actually used later.) The compressor of the first American turbojet (photo, top right), although similar in general structure and capacity to the Whittle unit, differed in its aerodynamic and mechanical design. Actually, its construction followed supercharger and industrial compressor design constants established in this country many years before. Test performance clearly proved the adequacy of the compressor's efficiency.

Hesitancy: Engineering Caution

Why, then, so much hesitancy in proceeding to actual construction in the United States during the 1930's?

You can probably attribute the reason largely to two factors that distinctly colored engineering thought at that time: First, the overemphasis on the high factory-test-stand specific-fuel consumption of the gas turbine plus failure to make an adequate comparison with the reciprocating engine under actual flight conditions or to take adequate account of the turbine's compensating advantages; and second, the absence of a sense of military urgency in the United States.

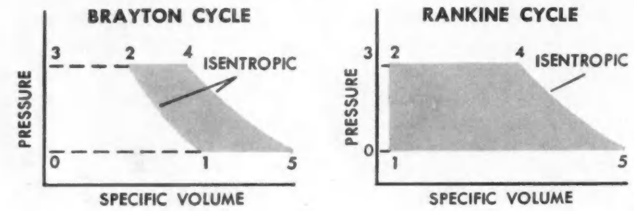
American design studies frequently ignored or paid insufficient attention to a most important fact. The specific fuel consumption of a reciprocating engine measured in a factory test must be multiplied to make it truly comparative with that of a gas turbine in flight.

An aircraft power plant's ultimate purpose is to provide propulsive power. Its over-all efficiency depends largely on its propulsive efficiency—a factor that does not enter at all into the test-stand performance because the propulsive efficiency depends on the airplane's velocity. But even when considering the propulsive efficiency, engineers often assumed too low an airplane velocity. They overlooked this fact: The use of a gas turbine, particularly a turbojet, would of itself so reduce the total drag that much higher airplane velocities would be possible, with still further increase of propulsive efficiency. (This snow-balling effect has proved of great importance in the aircraft gas-turbine's development.)

American engineering studies often lost sight of still other factors favoring the gas turbine, especially the turbojet. For example . . .

- Decrease of atmospheric temperature at high altitudes results in a marked improvement of cycle efficiency.
- Utilization of at least some of the turbine output directly in the form of kinetic energy of the exhaust gases. This eliminates losses incurred when converting energy into shaft work.
- Ram pressure at high airplane velocity increases the over-all pressure ratio and cycle efficiency. It also transfers part of the compression process—at extremely high airplane velocities, perhaps the greater part—to the intake duct, where it can sometimes be carried out more efficiently.

But even the increase of rotary compressor efficiency resulting from the larger flow required for a gas turbine, as compared with a supercharger, was usually underestimated. Magnification of this gain in the specific fuel consumption was either underestimated or overlooked. And the potentialities of the



WHY GAS-TURBINE DEVELOPMENT TRAILED THE STEAM TURBINE

The difference in properties of a gas and a vapor results in a large difference in the amount of negative cycle work—or work required to compress and deliver the working medium.

Most conventional steam-turbine power plants operate on the Rankine cycle with the gas turbine following the Brayton cycle. The work of compression and delivery of air indicated by the area 0, 1, 2, and 3 in the Brayton cycle corresponds to the work of compression and delivery of the boiler feed water indicated by the same area in the Rankine cycle.

Although the same in principle, the two cycles differ so widely in magnitude of work that a great difference in cycle characteristics results. Negative work of the Rankine cycle is negligible because the work required to compress and deliver a liquid is small compared with that required for a gas. Usually a diagram of the Rankine cycle does not show line 1 and 2—the only reason, by the way, for making a distinction between the Rankine and Brayton cycles.

The negative work 0, 1, 2, and 3 of the Brayton cycle is a large fraction of the positive work of expansion and delivery 3, 4, 5, and 0 available from the hot gases—perhaps as much as two thirds even for ideal isentropic processes. Thus the net useful output 1, 2, 4, and 5 is the difference between two values, large relative to the net output itself, and the gas-turbine plant consequently has certain striking characteristics.

First, if any losses occur during the compression process, the actual negative work required will be greater than the area 0, 1, 2, and 3 and if any losses occur during expansion, the actual work of expansion and delivery will be less than the area 3, 4, 5, and 0; thus the actual net output will be less than the area 1, 2, 4, and 5.

But even when these losses become large enough so that the net output is zero, they are still small relative to the total work or, let's say, that the corresponding component efficiencies are still high. The steam-turbine plant delivers some net output even with the efficiency of expansion only slightly above zero; whereas the gas-turbine plant requires high efficiencies of compression and expansion, say about 70 percent for each, before it can deliver any net output.

But this isn't all. Even if these component efficiencies are high, the net output will still be low—unless the theoretical net output 1, 2, 4, and 5 is reasonably large to begin with. This requires that the specific volume at point 4 be large relative to the volume at point 2. In turn, this requires that the temperature at the turbine inlet be high relative to the temperature at the compressor inlet. Usually the ratio of these absolute temperatures must be at least 3 to 1 to obtain any net output.

Because the gas turbine must operate at high speeds and, consequently, is subjected to high stresses, materials strong enough to withstand these stresses at high temperatures are essential.

axial-flow compressor for still further increased efficiency and volume flow weren't fully realized at first. Finally, engineers could operate the power plant at such high speeds that the weights of both compressor and turbine became small relative to the net power output. This output was the difference between two large amounts of power which were usually thought of as requiring much larger and heavier machines.

Let's turn now to the second factor that strongly influenced American opinion during the 1930's: the absence of military urgency, at least to the degree felt in Europe.

A turbosupercharger is similar to an independent gas-turbine power plant except for the absence of a combustion chamber. Production techniques were well developed for the turbosupercharger. (Shortly thereafter several hundred thousand turbosuperchargers were built to make possible the high-altitude flying of *Flying Fortresses, Superfortresses, Liberators, Lightnings, and Thunderbolts* in World War II.)

Yet the increase of scale involved in passing from turbosuperchargers to independent gas-turbine power plants necessitated not only new tools and other manufacturing facilities but also development of new metallurgical and manufacturing techniques. In general, operating stresses and gas temperatures required were no higher than for the turbosuperchargers, often less. But obtaining the necessary strength in some of the parts with larger dimensions proved more difficult. It isn't surprising, therefore, that in the absence of an emergency the large financial outlays required weren't favored.

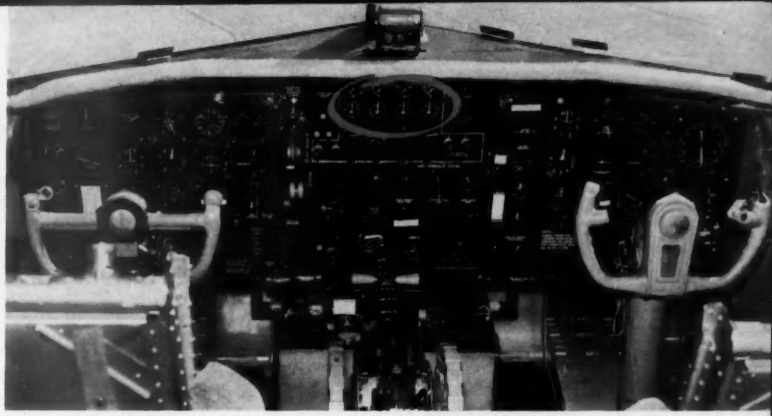
If it now appears that such development should still have been undertaken in the United States, the responsibility for the delay must be assigned partly to the military services. But industry must share the responsibility, too, because it didn't fully comprehend the potentialities of the gas turbine. Under the existing circumstances, however, actual construction logically and naturally should have begun in Europe. Only limited funds were available in this country for distribution among many pressing projects. And Europe's need for the aircraft gas turbine greatly surpassed that of the United States.

In Retrospect

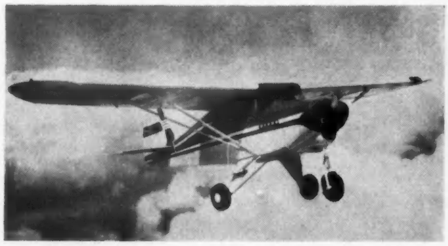
Looking back, you can see the rather slow rate of progress that marked the gas turbine's development as long as engineers concentrated their attention on ground power plants.

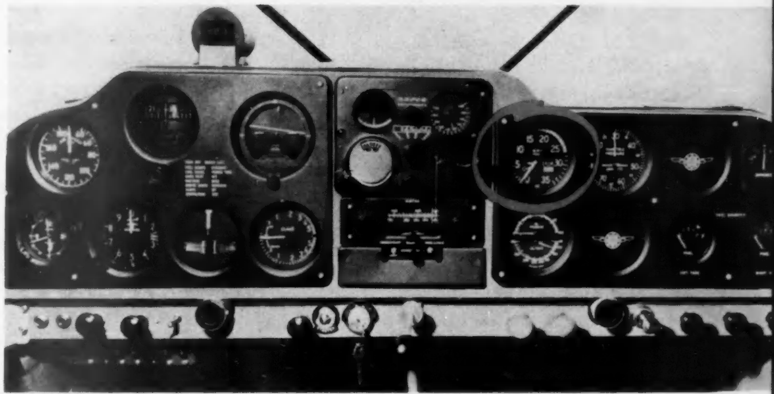
The aircraft application, completely unforeseen during all this long period of early development, proved so suitable that—with the favoring circumstance of a war emergency—its development accelerated tremendously. The aircraft gas turbine quickly became a practicable power plant, thus opening the way to acceleration of its development for other applications, too.

Spurred by the interest aroused by the successes in the aircraft field—with a constantly accumulating store of experience and technical knowledge and with financial support available to an unheard of degree—development of the gas turbine is now proceeding in many directions. And conditions are so favorable that they would have appeared fantastic to the pioneers. Ω



Whether in a jet-propelled Boeing B52 *Stratofortress* or a prop-driven Piper *Tri-Pacer* 150, tachometers (circled) are essential to the proper and economical function of aircraft engines.





Measuring Aircraft Engine Speed

Today's aircraft technologists want instruments that measure engine revolutions to a fraction of a percent while functioning in temperatures of 600 F.

By JOHN J. FRAIZER

Tachometers—basic instruments in any airplane—measure engine speed. You'll find them included among the hundreds of complex instruments in a modern transport aircraft. And you'll even find one among the few instruments in a Piper *Tri-Pacer* (photos).

In fact, the tachometer has appeared in some form on every powered airplane from the Wright *Flyer* of the early 1900's to the high-performance jet aircraft of today. While its importance to aviation—and the aviator himself—may be obscured by current technological problems of flight, you can be sure the tachometer will be around for a long time.

Mr. Fraizer, a previous contributor to the *Review*, came with General Electric in 1948. As an Advance Engineer, Aircraft Instruments, Instrument Department, West Lynn, Mass., he presently develops integral lighting for aircraft instruments.

From Piston Engines . . .

Piston-powered airplanes still comprise the majority of aircraft in use. In such a plane, tachometers measure engine crankshaft speed. The pilot or flight engineer constantly checks the tachometer reading expressed in revolutions per minute (rpm). For the tachometer is usually the first instrument afected when mechanical troubles develop.

Often, serious damage to an aircraft engine can be avoided by shutting down the engine when troubles first crop up. During the ground check of his plane, the pilot does exactly this before takeoff. He "revs" his engines at full throttle; if they don't develop the necessary rpm for full power, he knows that something is wrong; and the airplane, therefore, should not be flown.

The pilot can also control his engine's fuel consumption by paying close attention to the tachometer. In the interest of economy, he will at all possible times operate his engine at the cruise rpm recommended by the engine manufacturer.

But even during an emergency, when he must operate his engines at more than cruise rpm, tachometer readings remain important. In this instance, they must also be carefully watched to prevent the engine speed from exceeding the maximum safe values specified by the engine manufacturer.

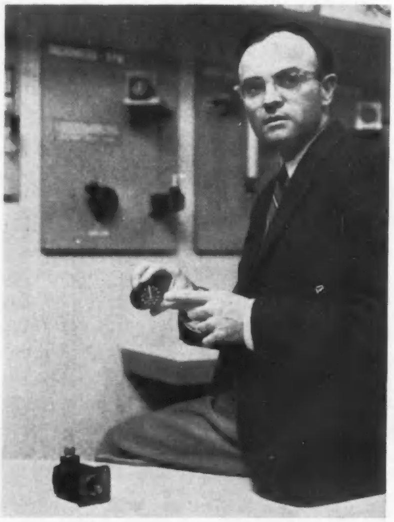
On multiengine aircraft, the pilot also uses a tachometer for synchronizing his engines. Because when not operating at the same rpm, piston engines can cause objectionable noise and vibration as you have no doubt experienced some time during your air travels. By running all his engines at exactly the same rpm, the pilot minimizes the vibration. Usually he does this by selecting one of the engines as a master reference, matching to it the rpm of the other engines. (With the aid of tachometer generators, this happens automatically in most modern aircraft.)

"Tachometer systems of extreme accuracy are needed to control jet e

. . . to Turbojets

As you know, turbojet engines came into general use toward the end of World War II. And though they operate on an entirely different principle than internal combustion engines, they still have rotating elements, namely the turbine wheel and compressor. With their introduction, naturally, many new problems have arisen for systems measuring engine speed. Turbojet engines operate at high speeds—so high, in fact, that material failures could result. Take turbine blades, for example: the high speeds create extremely high stresses. Overspeeding the engines will sharply reduce blade life; it may even destroy the turbine blades. Cruising range of rpm of turbojet engines is small—usually within a range beginning at 95 percent of maximum speed. For this reason the tachometer must be extremely accurate, quickly indicating small changes.

You can get a good idea of the role of tachometers in a jet-powered aircraft by relating air speed to changes in engine rpm. The air speed of a turbojet has much greater sensitivity to changes in engine rpm than a piston-powered—or, for that matter, a turboprop powered—aircraft. Consider, for example, a piston-powered plane and a turbojet flying side by side at 350 mph. Suppose both pilots advance throttles to increase their engine speed 1 percent. The piston-engined aircraft will increase air speed less than 3 mph; the turbojet will accelerate to a speed 14 mph greater.



TACHOMETER for jet aircraft displayed by author Fraizer receives electric impulses from engine-mounted generator (table).

In a word, then, jet aircraft—because of their extreme sensitivity to changes in engine speed—require extremely accurate tachometers.

Accordingly, most modern tachometer systems have calibration errors of $\pm\frac{1}{2}$ percent. Thus when a tachometer reads 90 percent, its true engine rpm may be anywhere from 89½ to 90½ percent of maximum. In a piston-powered plane, this would result in an air speed error of only 1.3 mph. But in a turbojet the error in air speed could be as large as 7 mph, again assuming both planes traveling at 350 mph. Although this difference may seem unimportant to you, at critical times—such as at landing or takeoff—it can be supremely important. To reduce the air speed error of the turbojet to that of a piston-powered plane would require tachometers having calibration errors of only $\pm 1/10$ percent.

All these considerations emphasize the increased importance of tachometer systems on aircraft powered by turbojet engines. What's more, you have to bear in mind that these accuracies apply over widely varying temperatures. For jet aircraft operate all over the world, in climates ranging from extreme cold to tropical heat.

Accurate engine-speed measurements also play a vital part in automatic control systems for turbojet engines. Engine speed combines with compressor discharge pressure, inlet temperature, and tail-pipe temperature to form an integrated thrust-selector control. By simply advancing this control, the pilot automatically gets more thrust from his jet engine. Automatically, fuel flow and the area of the jet nozzle are so regulated that the engine's temperature and rpm do not exceed the maximum.

Like Money in the Bank

To the pilot of a commercial airplane, the proper use of his tachometer means money in the bank. For by properly controlling engine rpm, he can effect savings in the weight of fuel that in turn can be utilized to carry additional revenue-paying passengers or freight. His proper control of engine rpm also means less wear and tear on engines, reducing overhaul costs.

On the other hand, to the military pilot, proper regulation of his engine's rpm means longer range and additional pay load in the form of armament. On some occasions, it can mean the difference between his getting back to an air base after a long mission or of running out of fuel and being obliged to make a forced landing.

During World War II, for example, the Air Force found that at many of its overseas bases some pilots had returned from a mission with adequate fuel remaining, while other pilots flying the same mission in the same type of airplane had returned with empty tanks. Looking into this situation, they discovered that many pilots who were running out of fuel were not operating their engines at the most economical rpm.

A man particularly adept at getting every mile out of a gallon of gasoline was Charles A. Lindbergh. He carefully observed engine rpm, no doubt because he learned to fly in a period when airports were few and far between and money for fuel was scarce. His ability to get the most out of fuel proved to be of utmost importance in his flight to Paris in 1927. On this flight, he conserved fuel so well that he landed in Paris with 85 gallons of gasoline left in his tanks—enough to fly an additional 1000 miles eastward!

Electrical Solution

Although the first tachometers were mechanical devices, in time engineers devised an electric tachometer system that comprised a generator connected close to the engine by a short flexible cable. An indicator remotely mounted on the pilot's instrument panel completed this system. Light and extremely flexible wires connected the indicator to the generator.

In early systems the indicator, actually a voltmeter with its dial calibrated in rpm, read the voltage output of the generator. But in later systems, indicators were frequency-sensitive devices with their readings a function of the generator's frequency output rather than voltage.

A frequency-sensitive tachometer is inherently better than the voltage type for several reasons. For one, frequency output of a generator—a direct function of the generator's shaft speed—is unaffected by such variables as vibration, temperature, or the changing resistance of connecting wires. Another big advantage: Indicators or generators

engines. To produce them, engineers may take a radically new approach."

can be interchanged without affecting the system's calibration. Thus if a generator is defective, it can simply be replaced without changing the indicator.

Despite these advantages, however, aircraft designers for many years did not favor electric systems because of the large changes in indicator calibration with temperature. According to a report issued by the National Advisory Committee for Aeronautics in 1927, the maximum error averaged about 10 percent for every change in temperature of 100 C. Other objections to electric systems included high initial cost, relatively heavy weight, and frequent calibration.

Principally for these reasons, electric tachometers were used only in multiengined planes where long flexible cables could not be tolerated.

After 1930, however, the use of multiengined airplanes increased, forcing instrument engineers to improve the accuracy of electric tachometers. They directed their first efforts toward improving frequency-sensitive tachometers. They managed to reduce overall temperature errors to 2 percent. But still another objection remained: Scale length of the indicator—limited to 270 degrees, that is, three quarters of the face of the instrument—didn't provide enough sensitivity to indicate slight changes in engine rpm.

Logical Evolution

Prior to World War II, instrument engineers developed a highly accurate frequency-sensitive electric tachometer that overcame all of the earlier objections (photo, opposite page).

Like its predecessors, a generator and remotely located indicator composed this instrument. The generator consisted of a permanent magnet rotor that rotated in an electrically wound stator. All the components were so designed that the generator could be mounted directly on the engine without being affected by vibrations. This eliminated any need for flexible cables.

The indicator appeared on the aircraft's instrument panel inside the plane. It comprised a synchronous motor, a drag-magnet assembly usually of copper or aluminum, a restraining spring, and a pointer plus a dial assembly.

The synchronous motor, a frequency-sensitive device, rotates at exactly the same speed as the generator. Neither length of lead nor generator voltages affect its operation. Coupled to the synchronous motor is the drag-magnet assembly—a grouping of opposed magnets having a small air gap in which a drag disc freely rotates. The drag disc is mounted on an independent shaft, with a fixed pointer at the other end.

A spring restrains the rotation of the drag disc. Thus the faster the drag magnets rotate, the greater the angle of rotation. Being a linear device, the restraining spring will rotate an equal amount for each equal increment of torque. For example, if a linear spring is rotated 10 degrees by a force equivalent to 10 grams, it will accordingly rotate 20 degrees for a 20-gram force, and so on.

Because the spring is a linear device and the force on the drag disc increases uniformly with increasing speeds, rotation of the pointer is a linear function of speed. By properly calibrating it against an rpm of known value, the system becomes a highly accurate measuring device.

In the years since World War II, accuracy and reliability of these indicators have steadily increased. Compared to early errors of 10 percent for every 100 C change in temperature, errors are now reduced to about ½ of 1 percent.

With performance like this, you can easily appreciate why electric tachometer systems of the drag-magnet type are now the most widely used in the aircraft industry.

What's Ahead?

The future of aviation is already being spelled out in terms of jet-powered airplanes designed to fly at high speeds and at extreme altitudes. Jet engines used in these planes will have an extremely high thrust—as well as a high thrust to engine-weight ratio—and operate close to critical stresses and temperatures. A relatively small increase in either engine speed or temperature could therefore cause serious damage or even destruction of the engine. Thus tachometer systems of extremely high accuracy are needed to adequately control these engines. Already, airplane manufacturers have requested tachometers with an accuracy of 1/10 of 1 percent. To produce devices having such an accuracy, instrument engineers may well have to take a radically new approach to tachometer design.

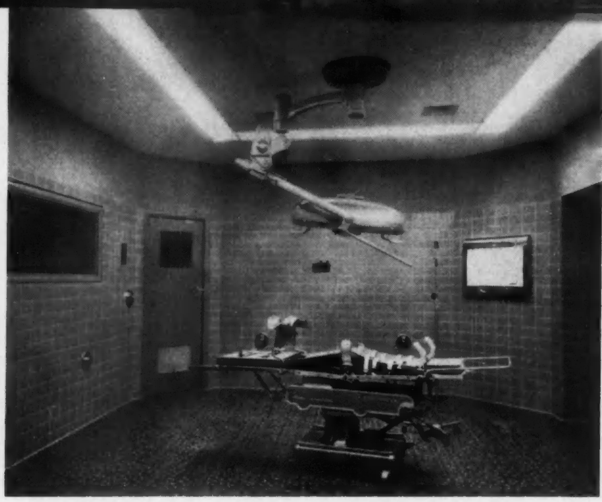
Jet engines characteristically consume a rapidly increasing amount of fuel as engine rpm decreases. High-performance jet aircraft will therefore have to cruise at extremely high speeds. But with too high an engine rpm comes the danger of engine failure or sharply reduced time between overhauls. For these reasons, the cruising speed range of these aircraft will be limited to about 5 percent of maximum engine rpm. In other words, the plane will cruise at engine speeds between 95 and 100 percent of maximum.

This factor will introduce complications in "human engineering." Because of the pilot's interest in this narrow range of speed, instruments with greatly expanded scales for easy recognition in this region will have to be provided. It may lead to a form of an instrument in which the pointer rotates 90 degrees —that is, one quarter of a circle—for engine rpm up to 95 percent of maximum. For rpm from 95 to 100 percent of maximum, the pointer would sweep out 270 degrees—or three quarters of the instrument's face—thus providing much greater accuracy in the cruising range.

But tachometer generators for these new high-powered engines will have to meet even more stringent requirements. Mounted directly on the engine, they'll have to perform at temperatures as high as 600 F. This factor alone will require the use of new materials and insulating techniques. Additionally, generators will have to withstand greater vibrations and shock while at the same time being physically small and light in weight.

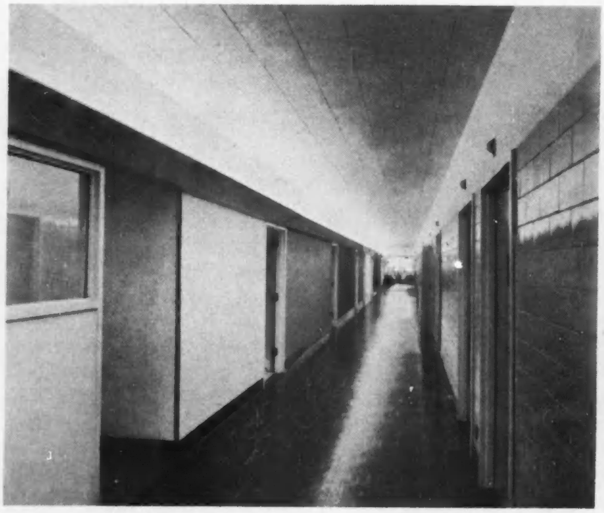
Certainly, the tachometer is destined to play an important role in jet-propelled aircraft. But, as you may have already surmised, some signs suggest that one day its usefulness will be greatly curtailed.

When will this occur? In the distant future when rockets replace jets as the power plant in aircraft. Because rocket engines have no rotating component, they naturally won't need a tachometer. Until that distant day, however—who knows how long—the tachometer will continue to function as one of the most important of aircraft engine instruments. Ω



Surgery Fluorescent lighting plays an important role in operating areas. Built into ceilings, it supplies "fill-in" light in much the same way as on a regular theater stage—giving shadowless illumination for better working comfort.

Reception Rooms Lighting, architecture, and decorating go hand in hand in modern hospital waiting areas. Deluxe fluorescent lighting and incandescent lamps blend well—enhancing colors and providing a warm atmosphere.



Corridors and Nurses' Stations Cove lighting on one wall spreads diffuse light, adding to apparent ceiling width (left). Well-shielded fixtures also give good diffuse lighting, reducing glare.

Patients' Rooms Forty-watt fluorescent lamps in wall bracket above beds provide pleasant general lighting (left). A luminous wall unit, suitable for private rooms, can be used for reading, night lighting, and examinations.

What's New in Hospital Lighting?

Working as a team, lighting designers and engineers are not only making today's hospitals more visually efficient but also more attractive.

By HOWARD HAYNES and KARL STALEY

New concepts of decoration and lighting are rapidly changing the appearance of our hospitals. With the estimated $2 billion that will have to be spent each year from now until 1964 to meet the hospital needs of our expanding population, you can expect to see even more emphasis on lighting and decorating.

Attractive surroundings heightened by good lighting and decorating schemes are important in your home, your office —or in a hospital. And the effect of pleasant surroundings cannot be underestimated in a hospital where people usually undergo emotional strain and physical discomfort. A cheerful well-lighted room can do much to help mental and physical healing.

Both Mr. Haynes and Mr. Staley are with the Large Lamp Department, Nela Park, Cleveland. Mr. Haynes—Specialist, Application Engineering—came with General Electric in 1937. He is concerned with health lamps and hospital lighting. Mr. Staley—Specialist, Engineering Publications—joined the Company in 1922. Author of Illuminating Engineering Society papers, his experience in lighting engineering is broad. His current assignment includes the writing and editing of reference bulletins on lighting.

Good hospital lighting is of importance to you as a . . .

VISITOR—You like to find your relatives or friends in cheerful, comfortable, and quiet surroundings. Such an atmosphere increases your confidence in the care and treatment they receive. Dingy colors and antiquated lighting don't.

PATIENT—Pleasant surroundings help take your mind off your troubles, make you feel more secure, and make reading more enjoyable.

CITIZEN (Taxpayer and Community-fund Contributor)—An efficient, attractive hospital is a credit to your community. It helps upgrade the community's reputation, shows progressiveness, and creates excellent public relations. With older hospitals, relighting—combined with redecorating—presents a comparatively inexpensive way to update a building, thus gaining maximum value for the operating dollars you contribute.

The 7000 hospitals now in use are hard pressed to supply beds and services consistent with the high state of the art of healing. Perhaps it seems too much to ask that hospitals devote their slim resources to appearance factors, but a hospital that *looks* like a good place to get well in makes a vital contribution to public confidence in your community.

With the lamps and application techniques developed by the lighting engineer, the lighting designer incorporates higher lighting levels and more visual comfort. Cheerful colors, light furniture, and even colored bed linen and dishes indicate that the decorator has won a definite place on the planning committee. Cleanliness is still the watchword, but hygienic surroundings don't have to be stark and bare. Today, surroundings are regarded aesthetically as well as aseptically (Box, page 19).

Patients' Rooms

The patient's room of today (photos, above) is much less austere than it once was. Current lighting practice requires . . .

- Lighting for general illumination of rooms
- Reading lights for bed patients and ambulatory patients who can sit up in a chair
- Examining light for the visiting physician
- Night lighting for the after-dark needs of the patient and the hospital staff.

The style of reading lights for patients has changed for the better in re-

Gift Shops and Lunch Bars

Accent lighting emphasizes the merchandise in hospital gift shop (left). Combination wall and down lighting creates a pleasant dining atmosphere for staff and visitors.

Occupational Therapy

Good lighting lessens the strain and fatigue of the physically handicapped (left). Well-shielded commercial-type fixtures for shop training reduce glare and help prevent accidents.

cent years. In hospitals, more so than in other types of buildings, the trend is toward the use of built-in reading lights. Certain factors provoked this break away from traditional floor and table lamps: floor lamps must have a heavy base for stability, yet they still must be easy to move and adjust by the patient—a difficult combination. The patient wants to adjust the light himself without calling a nurse. If there's another patient in the room, the reading light shouldn't glare in his eyes.

The relatively high maintenance of both the lamps and the necessary cords that must be plugged into wall outlets also discourages the use of floor lamps.

The valance-board system (photo, left, page 17) provides the simplest type of fluorescent lighting in rooms with fixed bed locations. Pull-switches at the head of the bed control individual lights as well as the night light. If your child happens to be in a ward equipped with built-in lighting, all the lights will probably be controlled from one central position by the nurse in charge. "Lights out" becomes no problem.

Surgery

One recent innovation in hospital lighting generates 10,000 footcandles of illumination on an operating table. Equal to midsummer sunshine, this lighting level represents a milestone in the progress of lighting as a science. This type of illumination uses incandescent lamps because they offer a relatively small light source. Large reflectors attached to the framework above the operating table guide concentrated rays deep into incisions and body cavities. And while the operating light provides color-corrected light, heat-absorbing heat-resistant glass cuts down radiant energy on the operating table.

Fluorescent lighting also plays a role in the operating area (photos, top, page 16). Built into ceiling panels, it supplies "fill-in" light, much as in a regular theater stage. Fluorescents give shadowless illumination for better working comfort.

Corridors and Nurses' Stations

Lighting requirements for hospital corridors are much more demanding than for other public buildings.

For example, hospital corridors are almost constantly populated 24 hours a day. In the morning patients go to surgery, the cleaning staff begins its chores, nurses and doctors make their rounds, breakfast comes "up," dishes go "down." All these keep the area active. Later, some patients will be getting exercise (maybe by wheel chair); others will be returning from surgery; the hospital staff will be going back and forth distributing food, laundry, medical supplies, mail, and reading matter. And in the afternoon and evening, visiting hours mean still more activity.

Corridor lighting should be relatively uniform—well distributed so that the light does not fall off appreciably between luminaires. Today's best systems employ continuous luminaire strips or coves that throw some light toward the ceiling and other light downward along the walls, preventing excessive contrast between the lights and surrounding ceiling surfaces (photo, lower left, page 16).

Many hospital planners have "remade" wings of buildings by painting ceilings, dadoes, furniture, and floors in light tones. Such treatment raises the whole tone of these areas because light surfaces keep light in circulation.

Such light surfaces and surroundings prove their worth in corridors, particularly at night. Because indoor lighting levels are only two to four percent of outdoor daylight levels, dark walls, floors, and furniture don't appear very dark in the daylight. But at night such furnishings literally soak up the available light, usually resulting in a displeasing and depressing effect.

At a nurses' station—commonly at the intersection of two corridors—the trend is toward built-in ceiling lighting to match the style of the lighting equipment in the corridors (photo, lower right, page 16). The luminaires provide good diffused lighting, and the light source doesn't disturb patients in nearby rooms. In modern hospitals, you'll seldom find the traditional gooseneck desk lamp on the nurses' desks. It has been replaced by a built-in fixture.

Reception Rooms and Lunch Bars

More attention is being paid to brightening walls in lobbies, reception rooms (photos, center, page 16), as well as lunch bars (photo, top right, opposite page) and cafeterias. They'll usually show the decorator's freer approach to the style of treatment. Visitors—as well as the hospital staff—appreciate colorful draperies, bright furniture, and decorations on the walls that are gay and smart. Here, too, lighting and decorating go hand in hand. A touch of gaiety in the lighting atmosphere helps nurses and doctors to relax. And deluxe fluorescent lamps not only enhance colors but also provide an atmosphere of warmth.

In the newest hospitals, the gift shop (photo, top left, opposite page) reveals all the latest brightness accents and techniques of their counterparts in modern shopping centers.

Other Areas

The service areas of modern hospitals no longer have the place of stepchildren when it comes to lighting. Here the equipment must be prepared and checked; cleanliness has priority. But attractive colors and fluorescent lighting do much to improve morale and good housekeeping. In service areas—the sterilizing room, utility room, central supply, laundry, offices, and kitchens—lighting conforms to standards that apply equally well to similar areas in commercial or industrial installations.

Germicidal lamps also play a big part in hospitals today. Their chief function: Disinfect the upper air and aid in preventing cross-infection.

Teamwork

Thus in a hospital, the lighting designer must utilize his skills to devise systems that most nearly meet the physical, psychological, and budgetary requirements of the hospital.

Lighting designers, decorators, and architects—usually independent consultants who manage their own firms—contribute fresh ideas in the use of light and color, setting important trends that help insure the well-being and efficiency of the staff and patients of today's hospitals. The other member of this team—the lighting engineer—backed by the extensive facilities of a large-scale business enterprise, designs and develops the lighting systems that best meet the needs and desires of the customers. Using their talent and skills, the lighting designer and architect then apply these systems to produce the best environment.

This relationship between a large-scale enterprise and the skills of smaller businesses results not only in better products and service to the American people but also in expanded growth opportunities for lighting designers and architects. Ω

How One Hospital Avoids that Institutional Look . . .

These comments on the new Lake Shore Hospital, Long Island, NY, appeared in *Architectural Forum:*

"Everybody planning hospitals these days aims at 'uninstitutional' atmosphere. Few achieve it. . . . This is Interior Designer Maria Bergson's first hospital job; she took nothing for granted, from patient lavatories to corridor lighting. Her new broom swept away one 'institutional' cliche after another. Behind this success was a board of trustees and an administrator just as willing as she to try new ideas—an indispensable factor.

"The patients' rooms (photo) have an illusory 7-foot 'ceiling' formed by the top of the plastics wall covering and the line between the filmy ventilating net and the opaque portion of the cubicle curtains. This line—which is the same as the door headers—gives the cubicles an air of being well-proportioned little rooms when the curtains are drawn. Note the uncluttered walls and ceiling track in place of the usual 'shower-curtain' hardware.

"This is not the kind of 'humanizing' job that relies on pretty curtains. The pretty curtains are here—along with unusually handsome wall treatment—but they are the least of it. Designer Bergson attacked not merely the *look* of institutionalism; she aimed at the monster itself. Here are some of the things this hospital's semiprivate patients most appreciate: 1) privacy while tooth-brushing or washing; 2) privilege of reading in the middle of the night without disturbing other occupants of the room—an achievement that requires a new lighting-fixture design; 3) a place to keep a suitcase, closets for clothes, a guest closet; 4) ample space for bedside needs."

Modern Laboratories like the new $5-million Metals and Ceramics Building at General Electric's Research Laboratory, Schenectady, NY, will help determine what our future progress will be.

One-room Laboratory of the past—with its sharply limited resources of money, materials, and manpower—pioneered the way for today's scientific and technological accomplishments.

Can Scientists Be Prophets?

An eminent research scientist—comparing the past and present with the future—tells what you can expect to know about the world of tomorrow.

By DR. C. GUY SUITS

New Year's Eve, December 31, 1999, should be a big occasion. Almost all of you who missed the last turn of the century have thought—privately, at least—about your chances of being on hand to start writing a letter by putting "January 1, 2000" at the top of the page. Probably you have already computed how old you will be.

Although some of you might have to be a bit optimistic about longevity, you probably still find yourselves guessing what the world will be like when you prepare for that special New Year's Eve. Will you watch—on wall-size three-dimensional color television—crowds cavorting across Times Square enjoying the balmy winter weather specially adjusted for the occasion? Will the program include remote pickups from places where years don't have 365 days?

Dr. Suits is Vice President and Director of Research, General Electric Company.

And what will you actually think about the 20th century as you sing *Auld Lang Syne* to a whole 100 years?

Universal Guessing Game

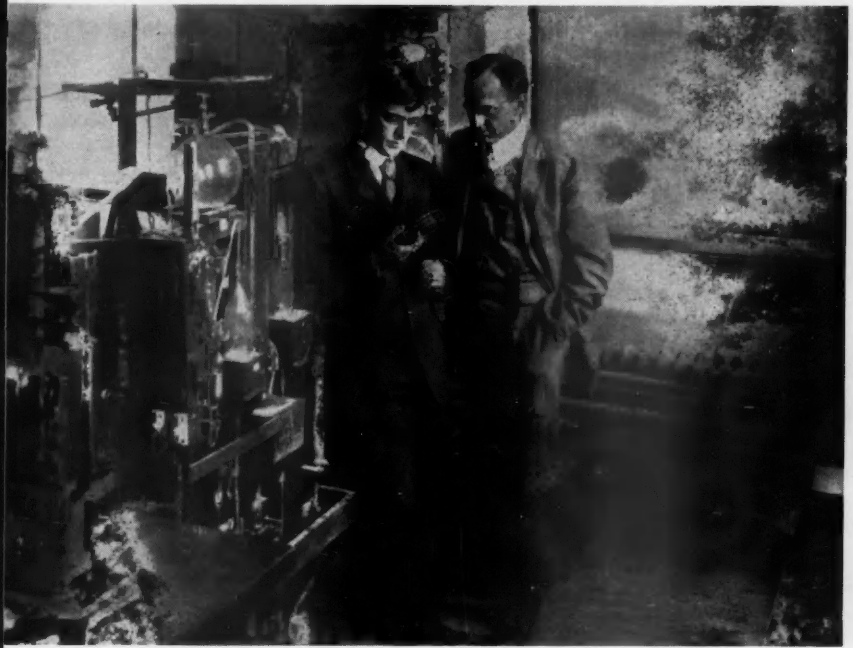
Less than a century ago, Jules Verne had a virtual monopoly on this business of guessing what science might do in the future. Today he would find the competition tougher. Everybody seems to be a prophet, amateur or professional, and this crystal-ball gazing isn't limited to children's television shows or the more fantastic pulp magazines. Some of the most respected and dignified journals have also succumbed. Wherever you look these days, there's an article, or an artist's conception, or a fanciful TV stage setting telling us what life will be like tomorrow.

Certainly there's nothing wrong with "looking ahead" and although an easy cliche, looking ahead represents one of the most important activities in modern civilization. For example, unless American industry looks ahead today, there may not be anything to see tomorrow. But, as with almost everything, this passion for prophecy can be overdone. The danger: Constant repetition sometimes makes prophecy *seem* to become fact.

To the man on the street, the practicing scientist may appear to be behind the times; and when he does something new and significant, surprise stems not from what he has done but from the length of time it took him. "I read about somebody doing that 10 years ago," is a comment the scientist hears more and more. Actually the *somebody* was probably the figment of a science-fiction writer's fertile imagination. *Today's fact may seem less dramatic than yesterday's fiction.*

What's It Good For?

Recently a group of General Electric Research Laboratory scientists discovered an entirely new physical phenomenon: amplification of light within a simple phosphor film. As a brand-new



phenomenon, it holds many future promises—some difficult to predict precisely. However, you can't announce something new in science without expecting to be asked that excellent question, "What's it good for?"

To some extent, predicting what the solid-state light amplifier will "be good for" isn't any easier than it would have been for, say, Lee deForest to foresee in 1906 the ramifications of the electronics industry made possible by his vacuum-tube amplifier.

Actually, seven years after inventing the Audion tube, deForest was taken into Federal Court on a charge of using the mails to defraud because "This strange device like an incandescent lamp . . . has proved to be worthless." In summing up the case, the prosecutor stated, "deForest has said in many newspapers and over his signature that it would be possible to transmit the human voice across the Atlantic before many years. Based on such absurd and deliberately misleading statements of deForest, the misguided public, Your Honor, has been persuaded to purchase stock in his company."

In announcing the new light-amplifying phenomenon, accusations of fraud were not the problems; because of the widespread science-fiction fad, we had the opposite kind of trouble. Some people thought the announcement meant more than it did; the simple facts of a significant scientific achievement were not enough for everybody. Some insisted on reading into it the development of a device the science-soothsayers had looked forward to for so long that their readers feel certain it is long overdue—the "picture-on-the-wall" television set. This is thought of as a thin screen hanging on the wall like a picture frame and a small box full of transistors, with the appropriate control knobs, resting on a nearby table.

Picture-on-the-wall television will surely be with us someday, and the new phenomenon of light amplification in a thin phosphor film may be an important clue to its development. To help answer the what's-it-good-for question, we said as much in our announcement. But because a thin, flat screen was used as a model to demonstrate the light amplifier and because all scientists worth their salt are presumed to be looking for the flat television screen, a surprising number of people thought we had something we didn't have—despite our efforts to explain in precise terms exactly what had been accomplished.

However, many do manage to keep the present in perspective amidst the profusion of prophets. Some of this group believe that when crystal gazing is to be done, the scientist should be the one to do it. And scientists have achieved a certain reputation for clairvoyance, but actually their best soothsaying results from the distressing fact that the transition time between basic discoveries in the laboratory and everyday use often takes 5 or 10 years. In other words, they aren't guessing about the unknown, they're prophesying that the known will be put to use.

The Scientist's Limitations

Of course, it's a speculative matter for scientists to claim that they know a particular new fact will be found or that a particular new invention will be made based on knowledge not yet discovered. However, you can ask the scientist what new things may be available *to the public* in 5—or even 10—years from now and expect a reasonably firm answer. The science that will provide these new things already exists in the laboratory. If you extend the period to 10 or 20 years, you can expect a reasonably good *educated guess.* The science that will provide these things is at least in the planning stage. For guesses beyond this, you had better turn to a crystal ball.

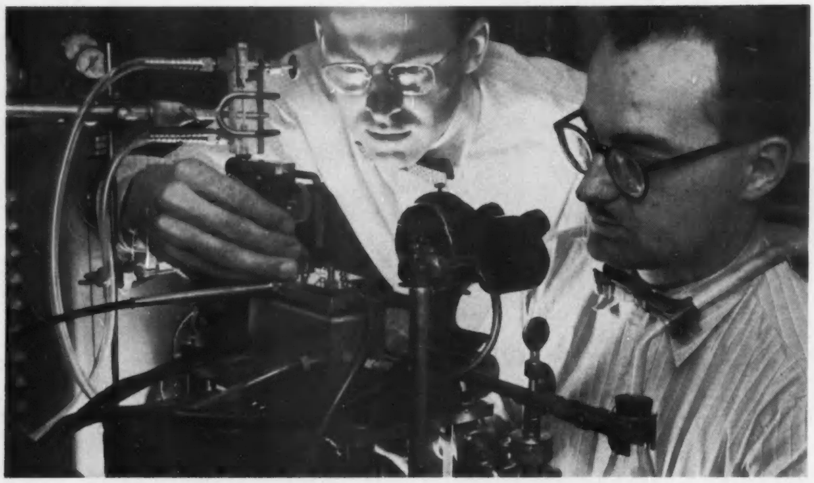
The scientist doesn't make a particularly good long-range soothsayer: partly because of his familiarity with certain physical limitations—the speed of light, for example; or the need for a positive magnetic pole where there is a negative one; or the basic restrictions that reside in considerations of energy such as its quantity, availability, and convertability. Although still cautious about it, the scientist probably will say that "some things can be done"—even the fantasies of the writer of a futuristic television program. At the same time, because he can visualize the laboratory activity required to attain a particular scientific goal, he may be appalled at the cost of converting papier-mache into solid reality.

The Decade Ahead

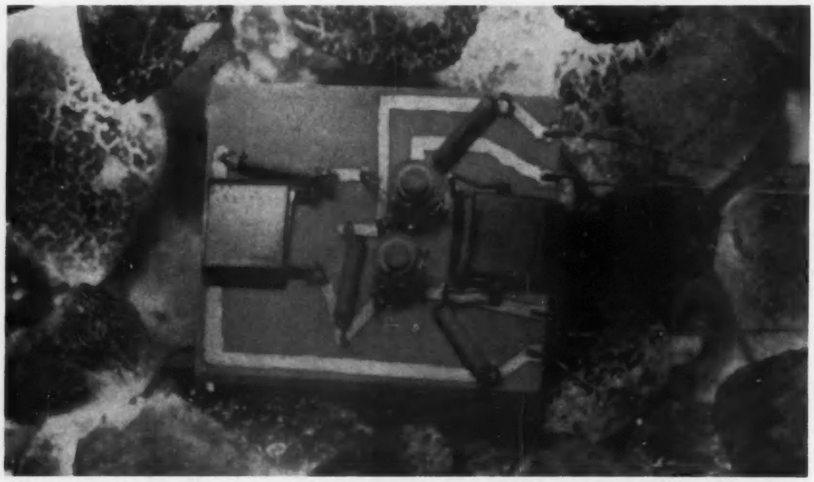
If the scientist can look confidently at the next 10 years or so, what does he see?

The things that are just ahead range from the indispensable gadgetry of modern living to the fundamental energy generation and conversion processes of modern industry. For one thing, in the next decade we will be completely saturated with electronics. And although it seems remarkable, the electron—discovered back in 1897—is still a lusty child, far from maturity.

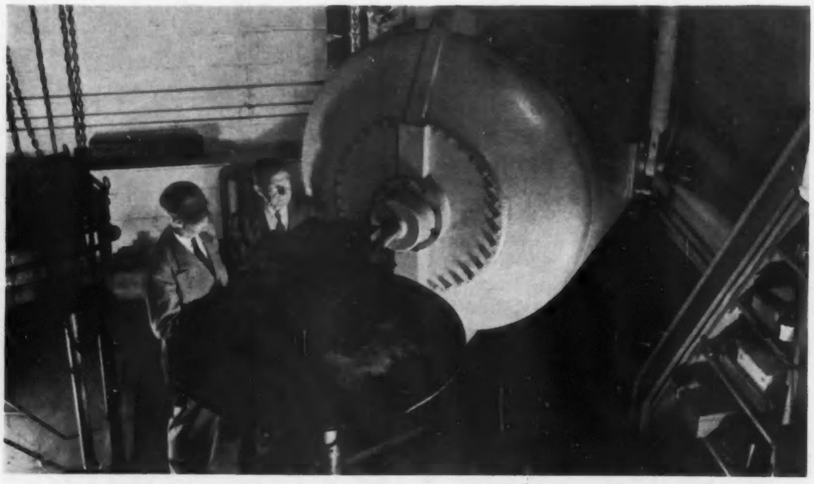
Tomorrow's electronics not only will be in the office, the factory, and the



SEMICONDUCTORS, rich relatives in the electronics family, promise to become indispensable in the coming decade. Scientists can grow silicon *hearts* for transistors (above).



HOT BRAIN CELL of vacuum tubes for computer makes yes-no decisions better red hot than cool—another sign of electronics' increasing growth in the next decade.



ELECTRON IRRADIATION already produces new materials and products that can be made in no other way. Experimental beam generator (above) irradiates food samples.

"... scientists can gene

farm but also will perform dozens of functions in the home, including cooking. In this next decade, factories will undergo important progress in automatic manufacturing, with electronic technology as the vital key to automation. By the end of this period, automation will have become an absolute necessity, because there won't be enough people to manufacture by present methods all the things we will need. This is arithmetic, not clairvoyance. A simple industrial forecast will show that we must produce at least 50 percent more goods and services in 1966, and we will only have about 10 percent more human effort with which to do it. The inevitable conclusion: Automation.

Semiconductors represent the rich relatives in the electronics family—rich in promise and potential. Semiconductors in the form of transistors and similar devices with electronic capabilities will be found everywhere during the next 10 years. In 1966, you'll wonder how we ever got along without them.

From the long list of things that will certainly come into being during the next decade as the result of scientific research, let's consider some of them. Chemicals are manufactured today principally by the controlled application of heat, pressure, and catalysts; production by means of these processes forms the basis of the vast chemical industry. We now have a new means of promoting chemical reactions—radiation—that will become increasingly important during the next decade. Light is radiation. We have known for years about chemical reactions that could be promoted with light; but atomic radiation, especially electron radiation in the form of electron beams, presents a new chemical action. The Research Laboratory has been working with *electron chemistry* for more than 30 years, and a few materials produced by electron irradiation—irradiated polyethylene is an outstanding example—have recently come to market. But in the next decade when electron chemistry comes of age, it will make possible a host of new materials and products that can be produced in no other way.

The most publicized use of electron chemistry has been the sterilization of food by irradiation, without heat. Many optimistic reports state this technique will eliminate refrigeration in the future. Progress has thus far been very slow.

But a recent report by the U. S. Army Quartermaster Corps states that more than 40 different foods, including several kinds of meat, when sterilized by this process were found *after cooking* to be acceptable by Army standards. Much remains to be learned before the process achieves widespread civilian acceptance. Looking two or three decades ahead, you may see the general use of radiation for food sterilization become possible, but no one can predict when the required new discovery will be made.

The specific examples just described offer a general area of great scientific promise—but one requiring a sharper focus. To illustrate, let's consider a few places where scientific progress is in the making.

Historically, understanding and knowledge of matter was first developed in diffuse form—for example, the kinetic theory of gases and the gas laws mark early milestones in scientific progress. Later more complex forms such as liquids yielded to study. Presently we are making great strides in understanding the still more complex interactions of matter in the solid state.

Further progress in this field certainly will hold important practical consequences. Energy conversion represents a promising area for solids. A few of the presently possible conversions: electricity can be changed to light, light to electricity, atomic radiation to electricity, heat to electricity, and electricity to cold.

Another area of solid-state progress with exciting possibilities is in the mechanical properties of crystalline solids. The role of defects in crystals and the remarkable properties of "perfect" crystals provides a hint of the great new knowledge to come from this research, inevitably affecting the world of mechanical things.

Planning Discoveries

Now let's take a look at the second decade ahead. Because we cannot simply look around the laboratory and see the accomplished results upon which it will be based, this extension—from 1967 through 1976—is much more difficult than the one just discussed. Particularly, one should hesitate to guess about the gadgets of this future period, although scientists can generally tell you what scientific discoveries the gadgets of tomorrow will depend on.

For the most part, the basic scientific discoveries for this period have not yet been made. Just what they will be and when they will be is a somewhat speculative matter. There are some plausible reasons for thinking that in the future scientists may be able to do a better job of predicting scientific developments.

Increasingly, scientific discoveries occur in areas of human need; for today's scientist isn't completely at the mercy of a capricious nature. The tools of modern scientific research have become powerful indeed; and under the influence and pressure of a frontal research attack, an unwilling nature may frequently be made to yield a desired result. Generally speaking, you will find some validity in the statement that to an increasing extent in the future scientists will determine what discoveries need to be made and then plan to make them.

The plans will, of course, not always be successful. Mother nature has the final word and may cast a veto. But the question of the final outcome of a research investigation is becoming more and more subordinate to the practical questions of probable cost, time required, and the availability of required scientific skills to accomplish the research. This will probably be true to a progressively greater extent in the future. Scientists plan to make discoveries in areas of great opportunity and need, and the powerful tools and skills of modern research will implement the planning.

But don't get the impression that basic research and pure exploration on new frontiers of science will disappear. Presently and in the foreseeable future, these frontiers seem to be limitless; they will continue to provide an outstanding challenge to the mind of man. In applied research where you seek a specific objective, the variety and effectiveness of the scientific techniques that can be brought into focus on a given problem will increasingly bend nature to our will.

Projecting the future—at least the future that will be based on science and technology—looks relatively easy for the next decade. The second decade confronts us with the prediction of discoveries which have not yet been made, making only general outlines discernible. However, those general outlines will in substantial degree conform to human needs and wants, and scientific research will provide powerful tools for shaping this future.

Looking beyond 1976, the crystal ball really becomes clouded. Even a guess at what *research projects* will be 20 years from now would be presumptuous. The scientist just plain cannot and should not try to say what the world will be like in 2000 AD.

Progress—A Sure Thing

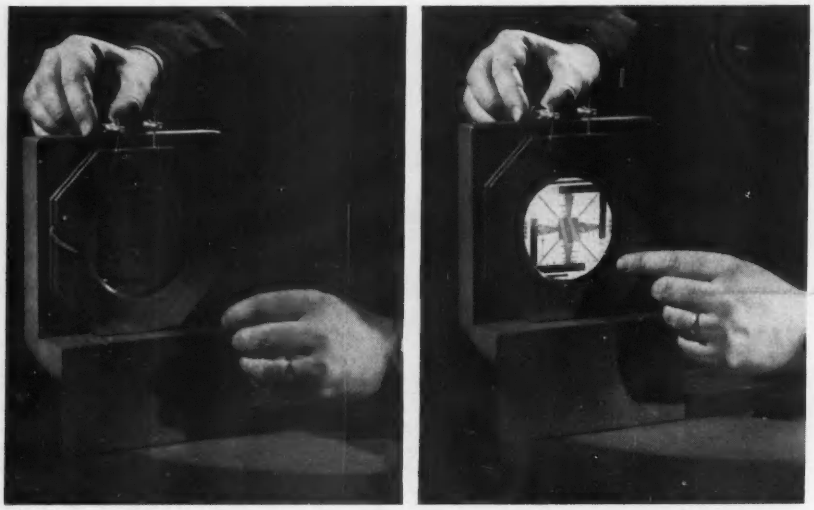
But the answer to "Will there be as much scientific progress during the second half of the 20th century as there was during the first?" is, "Yes, definitely. There should be *more* scientific progress between now and the year 2000 than there has been since 1900."

And this isn't inconsistent. Often a general question about the future can be answered but not a specific one. Ask if a shutout will be pitched in the National League on July 23 of this year, and the answer will have to be, "Nobody knows." But ask if there will be at least a dozen shutouts pitched in the National League during the 1957 season, and you will find plenty of baseball experts ready to say, "Yes, of course." Statistically, this seems to be a sure thing.

Similarly, great new scientific progress during the next four or five decades also seems to be a sure thing. Over the years, technological results have been produced pretty much in proportion to scientific efforts. You don't have to be acutely perceptive to assume that this correlation between research and progress will continue. Exactly *what* all this effort will produce cannot be foreseen, but *something* will be produced.

To justify great expectations for the future, you need only compare the scientific effort of the present with that of the year 1900. That year marks the beginning of the golden age of technological progress. But who would have guessed it from the amount of scientific research then being conducted?

If two men working on a flying machine in a bicycle shop constituted the promise of a multibillion-dollar industry 50 years later, what can you anticipate from the aviation industry's present research budget of nearly half a billion dollars annually? If "proton" and "electron" did not appear in most dictionaries published in 1900, how shall you compare progress in atomic energy during the past half century with what we can expect during a 50-year period starting



LIGHT AMPLIFIER, a phosphor film, may be clue to better television sets. Ultraviolet image on test screen brightens when electric field is applied to special phosphor.

with years when the annual expenditure on the atom alone reaches nearly $2 billion?

In no area do you find the difference or the future promise greater than in *industrial* research. Today, thousands of businesses—large and small—realize that they must invest in technological progress to meet competition. Many industries, some more than others, realize that new fundamental scientific knowledge represents as important a raw material as the tangible stuff from which products are made. But in 1900 industrial research as we know it now was nonexistent. A handful of firms had chemists trying to improve products, although the word *chemist* was more closely associated with the drugstore—a place where, surprisingly enough, you purchased mostly drugs. *Physicist* was not only a word unknown to the general public—it was practically unpronounceable!

Let's try placing the history of research in some kind of proper perspective. One famous idea for organized research dates back 300 years: Sir Francis Bacon, in *The New Atlantis*, described a "college of research" called Salomon's House. Its purpose was to ascertain "the knowledge of causes and secret motions of things and the enlarging of the bounds of the human empire to the effecting of all things possible." However, many years passed before Bacon's prophecy began to be fulfilled. During the subsequent Age of Invention, man—who had been making inventions of one kind or another from the time he first lighted a fire—finally began to become scientific by collecting some fundamental knowledge about how nature worked and then applying logical processes of reasoning to these discoveries.

As early as 1875, the application of science to industry began to receive recognition—but little support—from industrial leaders. The discoveries of science made their way into industrial practice in a variety of ways. The inventor, alert to the latent potentialities of any new scientific discovery, combined the work of academic scientists with his own inventive talents. Thomas Edison, for instance, was a careful student of scientific literature in a wide variety of fields. But the use of science by industry was not organized. Industrial research really began about 1900, but in a very small way. Until 1915, the *Readers Guide to Periodical Literature* did not list industrial research as a subject.

Early Industrial Research

The earliest growth of industrial research occurred in the industries that actually had been born in the laboratory or that were directly dependent on new knowledge for their growth. Even as late as 1920, the electrical, chemical, and rubber industries employed two thirds of all the research workers recorded in the first survey of the National Research Council. This first survey, taken in 1920, showed that about 300 laboratories were engaged in industrial research.

By 1940 the figures increased to more than 2000. The total number of people employed by the laboratories jumped from a few thousand to more than 70,000. The annual expenditure increased sharply to approximately $400 million. Even the depression failed to stop the march of research progress. Bankers, industrial executives, even stockholders took keen interest in the research activities of their companies and became convinced that "research is the best form of industrial insurance." If historians feel that the word *phenomenal* best describes the growth of industrial research during this period, what word satisfactorily describes what has happened since 1940?

Fortune said recently, "Industry has been on a research *binge*." Nearly 3000 companies now maintain industrial laboratories and employ over 250,000 people, including well over 100,000 scientists and engineers. Today you can measure the expenditures in billions; last year industry spent $2.7 billion for research and development. Admittedly, this figure covers everything from the purest fundamental research to some fairly routine engineering. Also this phenomenal growth in total effort exists more in the areas of applied research and development than in the area of basic research—a matter of proper concern to many analysts of the present situation.

Today's Outlook

But even assuming that slightly less than 10 percent of the nation's total research budget of $4 billion—including government and academic research as well as industrial research—goes for basic research aimed at finding new fundamental knowledge, this figure still represents an almost unbelievable increase over the corresponding figures of 1900. Certainly the comparison provides a reliable background for optimistic future forecasts. Although you would probably agree that too small a segment of the total research and development budget finds its way to basic research, the growth of the entire circle has been so great that even a narrow slice of the pie contains considerable nourishment.

In view of the established correlation between research and progress, who will say that science cannot produce more in the next half century than it did in the last?

No specific predictions as to what life will be like on New Year's Eve, December 31, 1999 can be made. But the prospects are good. Scientific progress—if it continues to depend on the best in men's minds and to survive in spite of the worst—will provide things not found in today's wildest dreams.

I cannot guess how it will be, but I would certainly like to be here. Ω

ENGINEERING SOCIETIES OF AMERICA

TWENTY-SECOND OF A SERIES

AMERICAN WELDING SOCIETY

By J. G. MAGRATH

The welding business in the United States is expected to reach, and pass, the annual billion-dollar mark soon. This figure clearly indicates the vital contributions that the welding industry makes to the industrial and financial structure of our nation.

And though you may be unaware of it, routine activities bring you into close association with welded products in your everyday life. Today's household furnishings and appliances, transportation vehicles, and buildings offer only a few examples of such products.

With proved procedure and safety, welding engineering permits the construction of modern structures and products of better design and utility in low-cost mass production. Internationally accepted as a necessity in metals fabrication, welding has become an engineering and metallurgical profession.

Early History

The American Welding Society Incorporated (AWS) represents the welding engineering profession and all those interested in advancing the knowledge of this increasingly important field.

Founded on the basis of a constitution adopted on March 27, 1919, the Society actually began as an outgrowth of the Welding Committee of the Emergency Fleet Corporation, U.S. Shipping Board. During World War I, this committee—working with the National Council of Defense—was responsible for expediting construction through the use of welding. AWS was originally organized as an agency for coordinating welding activities as well as codifying, assembling, and distributing knowledge relating to welding.

Dr. C. A. Adams, a director of the American Bureau of Welding, was the Society's founder and first president. The Board of Directors consisted of 24 men, many prominent in industry. At this time, membership totaled about 200. The Justice of the Supreme Court of New York State approved the Society's Certificate of Incorporation in February 1932.

No account of AWS would be complete without mentioning Miss M. M. Kelly who retired from active duty as Secretary and Assistant Treasurer in 1949—after 30 years of service. By action of the Board of Directors, Miss Kelly was given the title of Secretary Emeritus.

Today the Society has gained worldwide recognition as the leading scientific and educational welding organization as well as the authoritative source of information on the welding and cutting of metals.

Membership

The 12,450 members of the Society reflect a broad range of occupational and professional interest: 30 percent engineers of various classifications, including draftsmen and designers; 13 percent metallurgists, physicists, and educators; 28 percent plant management, both superintendents and supervisors; 7 percent sales promotion, advertising, and public-relations personnel; 7 percent welding-plant owners and contractors; 7 percent welders; 3 percent miscellaneous professions and occupations; and 5 percent corporation officers of industrial organizations. Such a percentage of corporate officers, seldom found in societies not devoted entirely to managerial problems, indicates how vital welding is to industry. Executives strive to keep abreast of the most recent developments in welding, welding engineering, cutting, and the allied processes. For such knowledge affects all levels of a fabricator's organizational structure.

The growth of national industrial support of the Society's activities further indicates the importance of welding in industry. Today 141 National Society Sustaining Membership Organizations and 268 industrial companies classify as an AWS supporting company—one having at least six of its personnel registered on the Society rolls in a membership classification. Some supporting companies have as many as several hundred.

Section Activities

The Society's Sections encourage the exchange of welding ideas. More than 80 Sections located in industrial areas throughout the country service the entire AWS membership. In recent years, the Sections have held about 600 meetings annually with attendance exceeding 35,000. Activities include: talks on latest welding developments and everyday welding problems, educational lectures, welding clinics and live demonstrations, inspection trips to important industrial plants, regional conference and symposia, and social meetings.

Publications

The Society published its first *Journal* in 1919, but limited finances forced publication to be discontinued. During the following two years, *The Welding Engineer* served as the official AWS organ. This magazine generously donated two or three pages each month for both the news of the Society and the papers presented at its meetings. However, in January 1922 the Society undertook monthly publication of *The Welding Journal*, with W. Spraragen as editor. When Spraragen retired 32 years later, B. E. Rossi became editor.

The Welding Journal includes informative articles on welding developments, providing useful information for all members—engineers, designers, metallurgists, production personnel, and technical executives. In its pages can be found 6 to 10 articles plus regular editorial departments—such as New Products and Literature, News of Industry, Practical Welder and Designer, Society News and Events—and the Welding Research Supplement, 50 pages of technical reports on welding research work in the nation's university and industrial laboratories.

In 1938 Spraragen became editor of the first *Welding Handbook* and directed its publication jointly with S. Jacobus, chairman of the *Handbook* Committee. Their endeavor was hailed as an outstanding success. A new edition in 1942, under the direction of the same chairman and editor, met with equal success. The third *Welding Handbook* was released in February 1950, composed

Mr. Magrath serves the American Welding Society in the capacity of National Secretary.

AWS OBJECTIVES

You will find that the following published "Objectives of the Society" clearly summarize AWS's aims and motives . . .

- Encourage in the broadest and most liberal sense the advancement of welding
- Encourage and conduct research, both basic and applied, in all sciences as they relate to welding
- Improve the education and usefulness of personnel engaged in and associated with welding activities
- Engage in and assist others in the development of sound practices for the application of welding and related processes
- Disseminate welding knowledge through its publications, meetings, discussions, consultations, exhibits, and any other available means, thereby fostering public welfare and education, aiding in the development of our country's industries, and adding to the material prosperity and well-being of our people.

under the direction of Dr. H. C. Boardman, chairman of the *Handbook* Committee, and S. A. Greenberg, editor.

The basic source on welding information, the *Welding Handbook*, includes such subjects as: welding equipment and processes, how to weld the engineering metals and alloys, how to estimate costs and design for welding, application of welding in the major industrial fields, inspection and testing of welds, and welding standards and specifications. Prepared by the nation's leading welding experts, this AWS publication finds acceptance throughout industry as the reference authority on welding.

A unique pattern for publishing and distributing the fourth edition of the *Welding Handbook*, now in preparation, will provide the receiving members with a new volume annually and keep the total edition's chapters current. Consisting of five volumes, bound in hard cover and indexed, each book will contain about 500 pages with 12 to 15 chapters on related welding processes or subjects. One of the five volumes of this fourth edition will be issued each June from 1957 through 1961. Then in 1962 the revised Volume I will be distributed as the first volume of the fifth edition. F. L. Plummer, chairman of the *Handbook* Committee, and A. L. Phillips, *Handbook* editor, are directing the preparation of this fourth edition.

AWS also produces educational and technical manuals, providing through its sales library about 40 additional publications on welding and welding engineering from other organizations.

Technical Activities

No single phase of the Society's activities is more valuable than its technical services. Through its technical committees, AWS serves industry as well as individuals in industry by . . .

- Gathering basic information on welding and allied processes
- Preparing codes, standards, and specifications
- Assisting in relieving conditions where use of welding is restricted or prohibited
- Preparing practical and engineering manuals on welding subjects
- Assisting members in solving day-to-day welding problems by providing requested information.

Until 1937, Dr. Adams and Spraragen directed standardization and research activities. At that time, L. M. Dalcher became assistant technical secretary and in 1942 technical secretary. Following Army service, he reassumed the office. In June 1947, Dalcher resigned, and S. A. Greenberg moved to the position. On January 1, 1954, the Society expanded its technical activities by appointing E. A. Fenton as assistant technical secretary.

The Technical Activities Group, with A. N. Kugler as chairman, supervises the activities of more than 75 technical committees and subcommittees. These produce the Society's Codes, Standards, and Specifications—guides to more serviceable and more attractive welded products and the universally used basis for efficient high-quality production. More than 53 codes and standards cover all phases of welding activity including welding fundamentals, processes, procedures, definitions and symbols, filler metals, testing inspection and control, industrial applications, and safety.

National Meetings and Expositions

The Society's first Annual Meeting was held in the Engineering Societies Building, New York City, in 1920. The first out-of-town meeting was held the same year in Philadelphia. From 1927 to 1956, the Annual Meeting formed part of the National Metal Congress consisting of four or five societies interested in metals. The National Metal Exposition, held in conjunction with this Congress, displayed the latest advances in metals, including fabrication and heat treatment.

At these national meetings, AWS members and guests listen and talk to experts and see demonstrations of the newest welding equipment and processes. A few highlights of the meetings include: papers on all types of welding subjects; lectures on designing for welding and the welding processes; tours through outstanding industrial plants; presentation of awards; and national committee meetings on educational, engineering, and industrial activities.

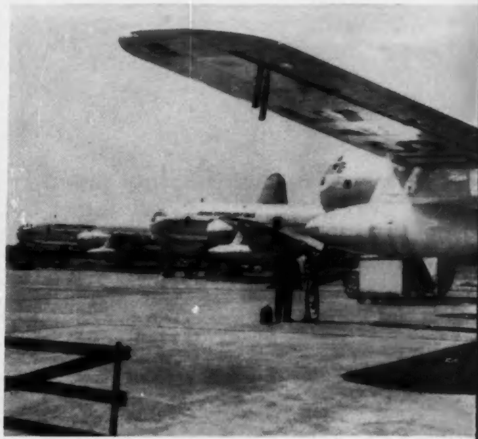
In June 1953, the Society held its first large-scale National Spring Meeting and Allied Industry Exposition at Houston, Texas, now held each spring in a key industrial city.

The AWS Welding Show introduces the latest industrial developments . . .

- Manufacturers exhibit and demonstrate their latest materials and equipment for all the welding and allied processes.
- Production executives find new ways to speed production and lower costs.
- Engineers and metallurgists keep abreast of better ways to weld their materials.
- Designers learn how to improve their products through welding.
- Maintenance engineers obtain practical tips on welding repairs and surfacing.

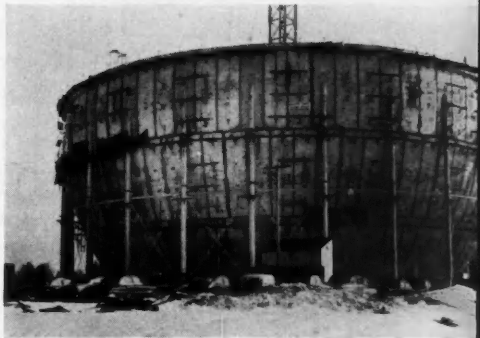
Approximately 2000 engineers convened at the Society's Annual Meeting each fall. At Buffalo in 1956 this Annual Meeting became an activity of the Spring Meeting. The Metals Engineering Branch of the American Society of Mechanical

AWS WELDING SHOWS introduce the latest industrial developments. Photos at the right suggest the scope of their application.

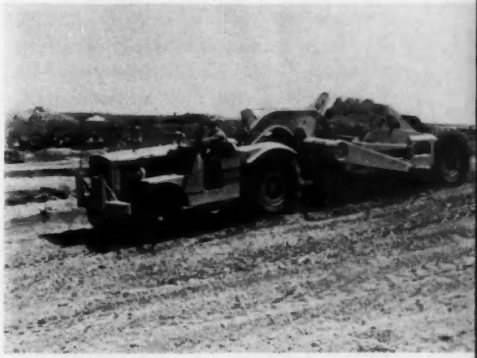


WELDING ON AIRCRAFT . . .

. . . BRIDGES . . .



. . . STORAGE SPHERE . . .



. . . and POWER EQUIPMENT

Engineers (ASME) held a parallel conference to provide the latest information on welding engineering to interested ASME members.

In April, AWS held its fifth Welding Show in Convention Hall, Philadelphia, in conjunction with its National Spring Technical and 38th Annual Meeting in Philadelphia's new Sheraton Hotel. Also participating, the Electric Welding Committee of the American Institute of Electrical Engineers held coordinated welding sessions on power load factor, power supply, and other electric welding problems. These coordinated spring events have become an accepted AWS pattern.

Affiliations

A member of the International Institute of Welding, AWS holds 35 affiliations with other national and international organizations. The society directly sponsors 105 activity and technical committees and councils that serve American industry through their scope of work in every phase of welding procedure. Through a separate organization, first known as the American Bureau of Welding and now as the Welding Research Council, AWS sponsors cooperative research in all areas of welding. In 1944 the U. S. Army Ordnance Department granted AWS the Distinguished Service Award for the Society's World War II services.

Awards Program

The Society supports an expanding awards program—some sponsored by AWS, others by interested industry. These awards are presented annually by the Society for work that contributes to the advancement of the science and art of welding. Among these honors are the Samuel Wylie Miller Memorial Medal, the Adams Lectureship, the Lincoln Gold Medal, the A. F. Davis Silver Medals, Honorary Memberships, the Henry Neitzel National Membership Awards, National Meritorious Certificate Awards, and about 20 Section Meritorious Certificate Awards. The awards not only create but also sustain the industry and members' interests in continued effort toward welding progress and achievement.

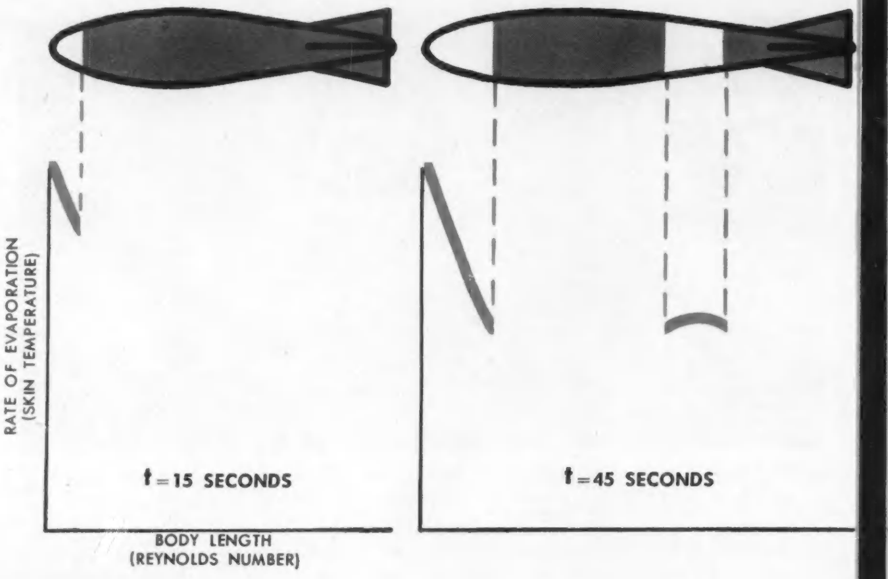
New Educational Program

A reorganized educational program comprises a master educational activities committee, under the direction of Chairman C. E. Jackson, plus an advisory committee consisting of interested university and school heads and a group of task committees, each responsible for a specific field of interest and need. These will provide for educational courses, in-plant training, extension training, college training, trade school and apprentice training, visual aids, and technical institute training.

The Future

The American Welding Society, welding engineering, metallurgy and research, and the welding industry meet, explore, and solve new problems daily. These may involve joining new similar or dissimilar metals, producing microscopic electronic assemblies, building larger and almost gargantuan monolithic structures, or constructing atomic energy housings and nuclear power plants. Past achievement encourages the Society and the welding industry to approach new projects with energy and confidence. Ω

Missile below, its surface prepared for wind-tunnel tests, gradually turns white as a result of heat generated by supersonic flow of air (step-by-step sequence). From visual observation, skin temperatures along the model's surface are charted directly.



Probing the Atmos

Practical approach
complete picture

By BENJAMIN DIAMANT

Just a few years ago, a test pilot tempted fate by resolutely flying his plane through the sound barrier. His success and the continual improvement of supersonic aircraft are largely attributable to the discovery and application of new experimental techniques.

But though technology conquered the sound barrier that hindered supersonic flight, another obstacle looms ahead to slow its pace. This is the thermal barrier —now called the thermal thicket.

Whenever you force an object through the air, the thermal thicket reveals itself in the form of aerodynamic heating. At low speeds, the heating is negligible and presents no problem. With each advance in the object's velocity, however, the problem multiplies; and aerodynamic heating becomes a barrier to further increases of speed.

Engineers have devised various methods of probing this barrier in the laboratory. One, a novel experimental procedure called the china-clay technique, provides a simple means of probing the thermal thicket. But a few basic facts about a body moving through air will aid you in understanding its application.

The Boundary Layer

When a body pierces the atmosphere, the air's viscosity, or resistance to shear, causes a thin layer of air to adhere to its surface (illustration, top, page 30).

Another layer that moves slowly past the body's surface lies next to this thin adhering layer of air. Successive layers move faster and faster until at a small distance away from the body the air relative to the moving body travels at its undisturbed, or free-stream, velocity.

The air's velocity close to the body varies from its free-stream value to zero and occurs in the region called the boundary layer—a region of specific interest to engineers. Within it, the friction between layers of air moving past one another generates aerodynamic heating.

Inside the boundary layer, air flow can be either laminar—that is, smooth—or turbulent. The condition depends upon a factor called the Reynolds number.

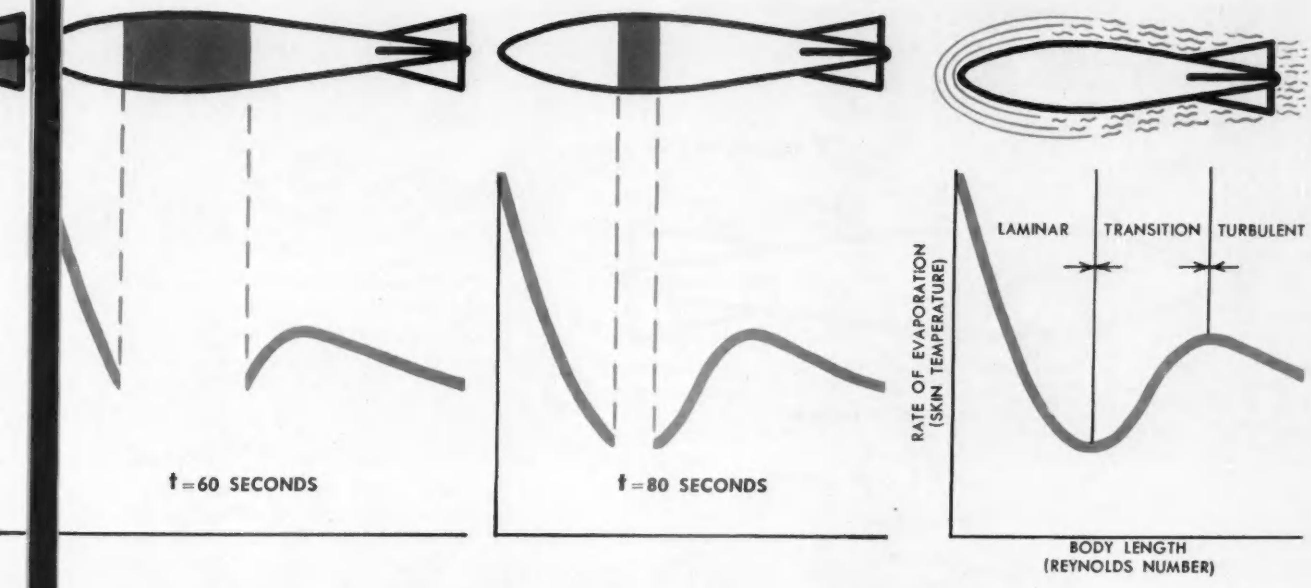
Reynolds Number Defined

A mathematical function, the value of the Reynolds number varies with air density, speed, and viscosity plus length measured along the moving body's surface.

For a given set of conditions—that is, fixed values for the body and the air's speed, density, and viscosity—the Reynolds number equals a constant times length along the moving body. Thus think of the Reynolds number as starting at some minimum value and progressively increasing as the air flow traverses the body's surface length.

The skin friction and skin temperature of a body moving through air have a definite relationship to the Reynolds number (illustration, lower, page 30)—adding to its importance. For a laminar

Mr. Diamant—Aerodynamics Engineer, Missile and Ordnance Systems Department, Philadelphia—started with General Electric in 1955. At present he conducts and plans programs to evaluate aerodynamic characteristics, makes optimum use of resources in supplying these characteristics, and provides advanced methods of technical evaluation.



...s phere's Thermal Thicket with China Clay

...ch n laboratory to boundary layer characteristics gives engineers a ...re f skin-temperature variations along surface of a moving body.

boundary layer, the body's skin temperature appears initially high but rapidly decreases as the Reynolds number increases. And the turbulent boundary layer—nonexistent at very low Reynolds numbers—always yields a skin temperature much greater than the equivalent laminar condition.

These conditions are fact. They exist and can be accurately determined.

Mathematics fails to tell the whole story in the region labeled *Transition Area*. Anywhere within this region, the boundary layer may alter its form from laminar to turbulent. And exactly where this transition takes place can only be determined experimentally.

Engineers usually carry out such experimental work on models in wind tunnels. If the model's skin temperature can be measured, the boundary-layer conditions can then be exactly determined.

Evaporation . . .

About the simplest way to measure temperature utilizes the principle of evaporation.

For instance, consider a cookie sheet covered with a film of water. If you placed the sheet over a burner on your kitchen range and turned on the heat, what would happen? The water would rapidly evaporate from the portion of the sheet directly over the burner. As the heat traveled to other sections of the sheet, water in these areas would gradually evaporate, too. By noting the water's rate of evaporation, you could obtain a relative measure of the cookie sheet's temperature. When the temperature is high, the rate of evaporation is high; when low, the rate of evaporation remains low also.

Accordingly, you could substitute *Rate of Evaporation* for the ordinate marked *Skin Temperature*, and the curves' shapes would be unchanged.

. . . and China Clay

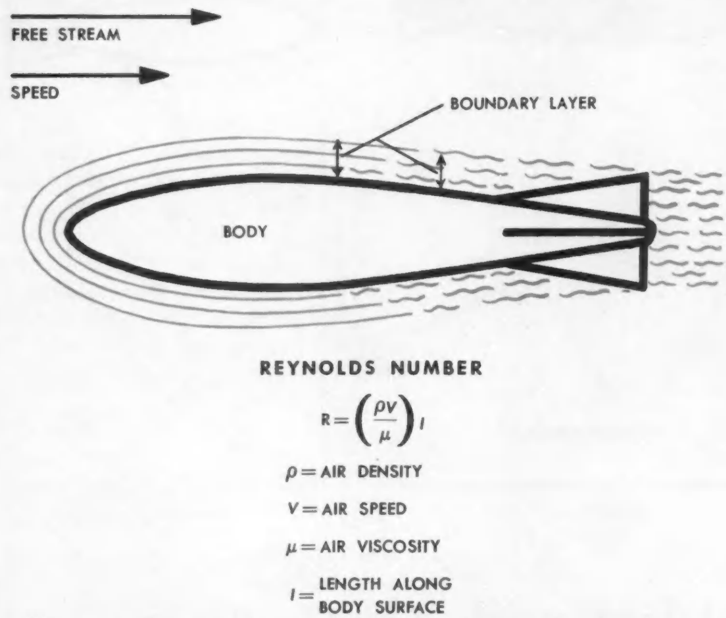
In the laboratory this is precisely what's done, except that china clay serves as the detecting medium. (China clay is an earthy substance commonly used in porcelain and refractory materials.) With this technique, engineers determine exactly when evaporation takes place by observing a distinct color contrast.

They first spray the wind-tunnel model of the body under investigation with black paint. After a drying period, a thin layer of china clay suspended in a lacquer solution is then sprayed on the model. When the lacquer solution dries, it hardens to a white absorbent finish.

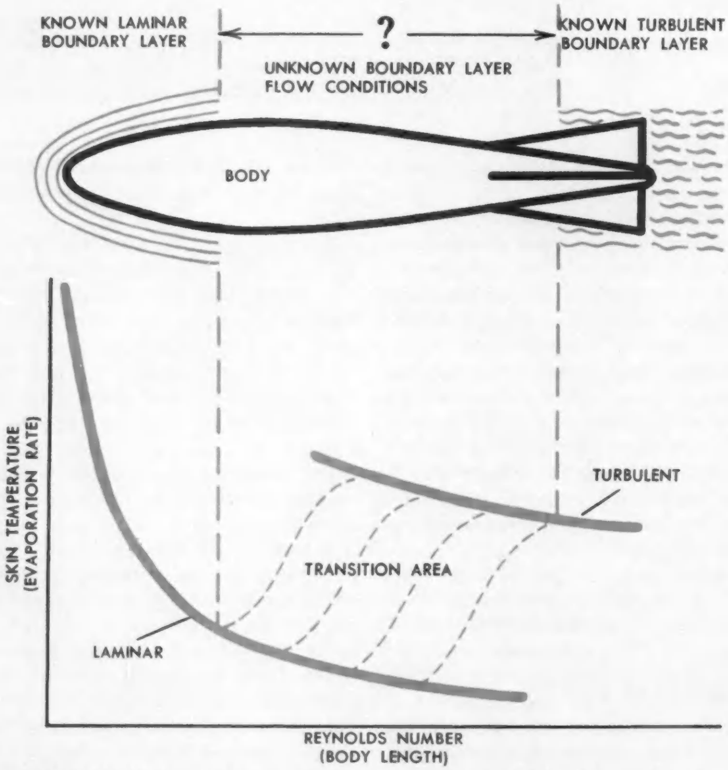
In the next and final step, the model is sprayed with oil of wintergreen. This liquid permeates the china clay so that it becomes transparent. The model once again appears black.

When the oil of wintergreen evaporates, however, the china clay regains its white appearance. By merely observing the change from black to white, engineers know when the oil has evaporated. If the china clay rapidly turns white on one section of the model, the surface temperature in that area will be high. If another section remains black for an extended period, its temperature will be low.

This simple connection between evaporation and skin temperature forms the



BOUNDARY LAYER varies from zero to free-steam velocity at finite distance from body; whether flow is laminar or turbulent depends on Reynolds number.



TEMPERATURE of a body moving through air relates to Reynolds number. For laminar flow, it decreases as body length increases until turbulence sets in.

basis for the china-clay technique in determining the boundary-layer conditions.

Vision and Time

The significance of the technique's application can be followed through a sample test with results plotted in a step-by-step sequence (illustrations, pages 28 and 29).

The model is prepared and installed in the wind tunnel, and then the air flow is started. After 15 seconds, you begin to see a small area of white on the model's nose. Characteristic of a laminar boundary layer, this white area indicates a region of high temperature.

After 45 seconds, the area enlarges slightly, and another white region becomes visible about midway along the model's length. This indicates the forward section of the turbulent boundary layer. Also the region extends rearward rapidly, and after 60 seconds the model's entire aft section turns white, while the white section at the nose slowly continues to enlarge.

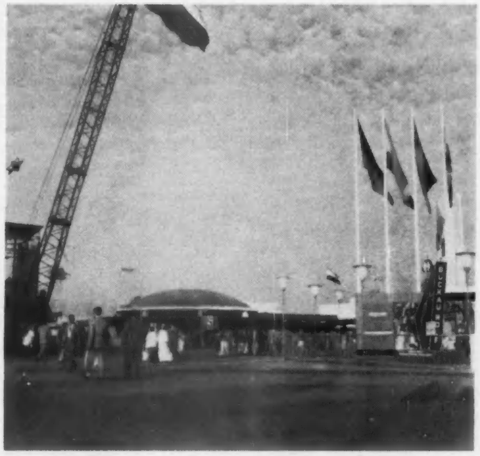
In about 80 seconds, the white nose area has extended rearward until just a small section in the middle of the model remains black. This section reveals the location of the aft portion of the laminar boundary layer. The complete curve can now be drawn to determine the nature of the boundary-layer flow around the model, thus pinpointing its transition characteristics.

Counterbalancing Thicket

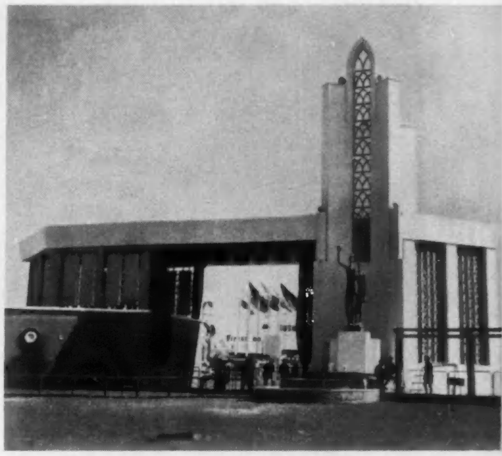
Like many straightforward methods of testing, the china-clay technique offers relatively inexpensive means of investigation. It provides a visual means of determining in the laboratory the skin temperature variations of a missile or aircraft configuration entering the thermal thicket. For permanent reference, the model's variations from black to white can be recorded with a motion-picture camera.

Naturally, no laboratory technique can fully supply data that would be obtained from a vehicle's actual high-speed flight. But based on results of the china-clay technique, engineers can determine beforehand the skin temperatures that the flight vehicle must withstand, and they can also evaluate new methods for controlling the boundary layer.

Armed with this information, engineers can design tomorrow's aircraft and missiles to better withstand the ravages of the thermal thicket. Ω



U.S. participation in International Trade Fairs at Karachi and New Delhi (photos) included daily House of Magic shows—demonstrating how American industry serves man and how research and engineering build a better tomorrow.



The House of Magic Visits the Orient

***Review* STAFF REPORT**

During recent years, many countries in Europe and Asia have held extensive international trade fairs. Our government people felt that the communist countries dominated these shows with their propaganda. Looked upon as an unhealthy situation, this was brought to President Eisenhower's attention. He then requested and was granted a fund for U.S. participation.

The President appointed a director, and an organization was set up in the Department of Commerce to handle U.S. activities. This group then sought help from industry—especially from firms doing international business.

When this group approached George E. Kendall—manager, advertising and sales promotion, Consumer Goods Export Department, International General Electric Company—he remembered the success of the House of Magic show on its South American trips. Consequently, he suggested it as a possibility. The Department of Commerce expressed their interest, and some representatives were able to see a show presented by one of our regular units in nearby Virginia. They liked it. And so the plans were laid to have Bill Gluesing—veteran House of Magic showman who accompanied the unit on its South American tour—take the show to Pakistan and India.

At the outset, Gluesing tailored the show to meet certain requirements: audiences, climate, and purposes of the show. He cut the program to 14 minutes—about one third as long as the typical House of Magic show. Because audiences would be standing, he thought the show should be short and compact.

The fair in Karachi—The Pakistan International Industrial Fair (PIIF)—scheduled to open in early fall was followed two months later by the Indian Industries Fair at New Delhi. Paul E. Lucey, an experienced lecturer who had just completed a tour with one of the House of Magic road units, was chosen to accompany Gluesing to the Orient. Upon their return to this country, a REVIEW editor interviewed Gluesing. Here is an edited transcript of their conversation. —EDITORS

Q: No doubt you had to make extensive preparations for your recent trip to Pakistan and India. Can you tell me what they involved?

Gluesing: Before we could get off the ground and leave for Karachi ourselves, we had to arrange for getting our equipment there. In the Company's General Engineering Laboratory here in Schenectady, we gave everything that was to be shipped an extra careful going over. Realizing the difficulty of obtaining spare parts in that sector of the world, we included a generous supply of replacements. For convenience in handling, we left all the pieces in their regular packing and carrying cases. Then the shipping department floated these cases in big wooden boxes designed for shipment by boat.

The boat that was to transport our equipment left Hoboken, NJ, in midsummer to arrive in Karachi five weeks later. Everyone cooperated so well that we met the deadline with several days to spare.

Paul Lucey and I followed the equipment in about a month. We flew from Idlewild International Airport. But actually, it wasn't that simple. When you go on a trip like this, you don't just say, "Gimme a ticket to Karachi." Plenty of preliminaries enter the picture.

For instance, my passport had expired, and so we both had to get passports to leave the United States. Then the Pakistan and Indian Consuls in New York had to issue us visas, or permits, to enter their countries.

We also had to obtain health certificates—required by the World Health Organization—that carried a record of a thorough physical examination. And for travel to certain tropical countries, it must carry a record of immunization against smallpox, cholera, yellow fever, typhus, and so on. I don't recall all the shots involved; but it took nearly a month to get them all.

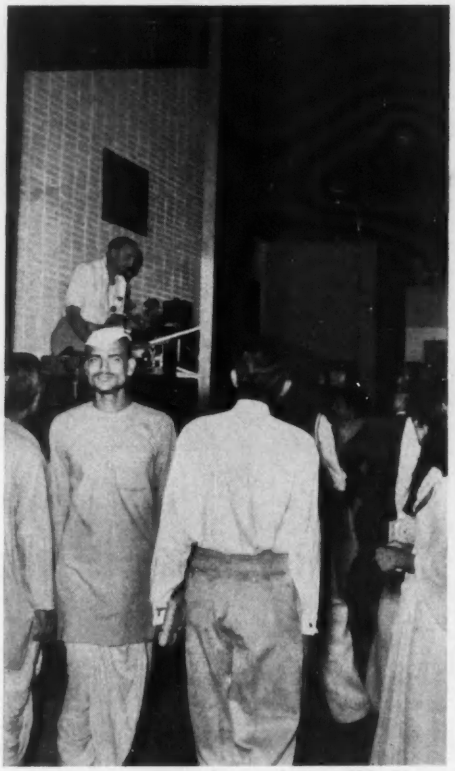
About the middle of the afternoon on August 15, armed with all necessary documents, we boarded a Pan-American Stratocruiser bound for London.

Q: Did you make any other stops in Europe?

Gluesing: After gas-up stops in London and Antwerp, we spent several days sightseeing in Frankfurt and Munich.

I particularly enjoyed the beauties of the boat trip down the Rhine and the majesty of the Bavarian Alps. But with me, unexpected sights or things contrary to preconceived ideas make the strongest impression. These sights lovely as they are created no such impression; they merely confirmed those I had gained from reading and seeing pictures.

On the other hand, the recovery since the war astonished me. A few ruins



The People

Enthusiasm and pleasure characterized audience response at the House of Magic shows. From a shy child haltingly ascending the stage to help with an act to onlookers crowding exit areas—all were welcome participants and a delight to showmen Bill Gluesing (above) and Paul Lucey (left). These men, who gave 20 or more shows each day for four months in India and Pakistan, found it a rewarding experience.

remained, but trim modern buildings and shopping centers completely overshadowed and outnumbered them. Everyone seemed industrious and efficient; in the cities and towns I sensed the atmosphere of a healthy economy.

The countryside and the farmland areas gave me the biggest surprise. For some reason I had pictured all European farmland as poor, depleted, and worn out. The farmland I saw wasn't worn out at all; in fact, it had been built up. Every acre and square foot of agricultural land that I saw in Germany showed signs of meticulous care and conservation—as though the people expected to use it for a long, long time to come.

I couldn't miss the contrast with much of the practice in our own country. In my native Wisconsin during my boyhood, I saw the first ploughing of many acres of virgin land. Less than 20 years later, its rich organic matter depleted, the best topsoil was being carried on its wasteful way down the Mississippi. I'm critical of land practices for I look upon agriculture as our most basic industry and upon good farmland as our most important asset.

But now, on to Karachi.

We left Munich after lunch, landed for plane servicing at Istanbul and again at Beirut. Then we made the long flight that brought us to Karachi. Local General Electric people met us, helped us clear immigration and customs, and took us to the hotel that was to be our home for the next two months.

Q: How did Pakistan impress you?

Gluesing: In a word, I would say *different*. Food, water, transportation, animals, and customs were strange and often new to me.

People moved about chiefly on foot or bicycle or hired rickshaw-bicycles. I did see some gas-engine-driven streetcars and some buses, also taxicabs and relatively few private cars. Motor trucks were not plentiful either.

Goods and materials were largely transported by camel and donkey carts and on the backs of these animals. The number of camels amazed me; they were as common in Karachi as horses were on our streets prior to 1915. On most streets the traffic scene was a peculiar blend of the old and the new. Even the ancient camel with ancient harness hauled ancient carts equipped with modern pneumatic automobile tires!

By inquiring, I learned that camel carts originally had high and narrow-rimmed wheels. When the streets of Karachi were surfaced, the camels could haul heavier loads on paved streets. Consequently, loads were increased, causing the wheels to cut into the pavement. This was hard on the street surfaces—usually blacktop on earth—and it became necessary to use pneumatic tires on camel carts.

Q: Did you see many cows or other domestic animals?

Gluesing: Yes, a few cows, as we know them. But usually herds of domestic water buffalo were kept for dairy and meat purposes. Goats outnumbered all other domestic animals. Raised chiefly for milk, meat, and hides, they were often hitched to little carts, too. And from goatskin come sandals, shoes, and harnesses.

To me, though, the most curious use of goatskin was the watering bag made of an entire goatskin cut off and open only at the neck. When full of water, it resembled a bloated goat and probably weighed about 100 pounds. Men carried these skins on shoulder straps. By manipulating the folds of hide at the open neck and pulling the skin around their bodies, they expertly controlled pressure and size of the water flow for watering gardens and other uses.

Q: Why this need for watering? Isn't the rainfall adequate in that area?

The Dignitaries

While in the Orient the House of Magic entertained many distinguished guests—Prime Minister Jawaharal Nehru and India's President, Dr. Rajenda Prasad; and from other countries King Mahendra Bir Kikram Shah Deva of Nepal and his Queen; Russia's Premier Marshall Nikolai A. Bulganin and Nikita S. Krushchev, head of the Communist Party Secretariat; and King Saud of Saudi Arabia.

Gluesing: No, Karachi is practically in a desert with an extremely short rainy season. We were there for most of it. They told us one rain fell just ahead of our arrival. Then during our third week, four to five inches fell in one day. The flooded streets halted all traffic. And flood damage at the fairgrounds caused a week's postponement of the Fair. Actually it opened two weeks later than the scheduled date.

The United States, Russia, United Kingdom, Czechoslovakia, Yugoslavia, Communist China, and India erected rather large pavilions. Several other countries had small buildings or exhibit space in buildings provided by the Fair organization. Each exhibiting country provided pavilion construction plans and supervision. But in India the method of working differs from ours. They do everything possible by hand rather than by machinery. For instance, digging trenches for foundations, pipes, and cables was all done with pick and shovel —often with two men on a shovel. One man held the handle as he pushed the blade in the earth. The second man, with a rope tied well down on the shovel, then pulled it and the load.

Concrete was handled by hand and by head. Several crews of men would mix and wet several batches of concrete by hand. Coolies—mostly women—would put a shovelful of concrete into a pan, then hoist it onto their heads, carry to the spot needed, and dump it. This human conveyor belt so fascinated me that I took several pictures. The coolies receive one rupee (about 21 cents) a day for this work.

In the U.S. pavilion, local people highly skilled in their particular fields did the concrete finishing, carpentry, and electrical work, using local materials. No doubt this was a strong point in our favor, in contrast to the many countries, chiefly communist, that brought in completely prefabricated buildings requiring less local skilled help.

One or two other pavilions exceeded ours in physical dimensions. But in attendance and interest, I think the U.S. pavilion surpassed all others—and for a good reason. Most of the pavilions relied solely on exhibits and displays, while the U.S. pavilion had the added feature of two shows to interest and attract the people.

You see, besides General Electric's House of Magic show, renamed *Adventures in Science*, RCA had a well-planned well-run closed-circuit TV demonstration. During dusk and the evening hours they presented programs of good local talent in a large glass studio. A limited number of people could see the program directly; thousands of others viewed it on more than a dozen receivers placed around the grounds.

Q: Did you have any difficulty drawing an audience to the General Electric show?

Gluesing: Our section consisted of a suitable small stage and a terraced audience area where 350 to 400 spectators could stand. At the entrance, adjacent to the traffic lane where visitors walked through the U.S. pavilion, we placed a couple of men. They directed people into the little auditorium by announcing, "The next science show starts immediately." Prior to this procedure, we tried persuasion by music but without the desired results. But now, once inside, the people seemed to like the show for word of it spread. After the second day, we seldom played to less than a full house.

Language presented a problem, of course. Paul and I alternated our English shows with shows in Urdu—the language of Pakistan. We hired two local men to read the translated script in Urdu while we operated the equip-

WHAT IS THE HOUSE OF MAGIC?

The House of Magic Show represents a collection of science demonstrations originally created and presented by members of General Electric's Research and General Engineering Laboratories in the 1920's. Floyd Gibbons originated the name House of Magic in 1926. But this name was not applied to these science shows until an early version of them opened at the Chicago World's Fair in 1933.

People viewed it at the Chicago, New York, and San Francisco World's Fairs, as well as at many other regional and state fairs held throughout the country.

After the New York World's Fair, several units were prepared for showing in high schools across the nation. But World War II cut short the life of these units. Early in the war, two units were made available to the USO for scheduling at service bases in this country. In recent years, several units were inaugurated chiefly for high schools.

At present the House of Magic units are primarily geared to stimulate junior and senior high school students to prepare themselves for higher education, especially in the fields of science and engineering. Though student audiences receive the major emphasis, another unit serves as a public relations tool before a variety of audiences. International General Electric frequently used this unit in Latin America as did the U.S. government in other countries.

For the past five years, General Electric has used members of the Company's Advertising and Public Relations training program to man the shows. Each man serves in this capacity approximately one year. At present six men staff the units along with William Gluesing.

Gluesing started with General Electric's Test Course, Schenectady, in 1923. His hobby as an amateur magician created sufficient interest to bring him into association with commercial exhibits; a year later. The House of Magic gradually evolved from these exhibits; and since its introduction as a special presentation in 1933, he has been exclusively concerned with the show and science demonstrations both in the United States and foreign countries.

ment. This way, four of us gave 24 to 28 shows a day. Considering the hours—5 pm to midnight—it meant four shows an hour with only one minute to reorganize equipment.

Q: Could the audience evacuate and refill the place in that short time?

Gluesing: This may come as a surprise: Only one quarter of the audience changed between shows. The other three quarters entered and left during the show. It made for confusion, but we learned to live with it.

Included on the program were several of our most effective demonstrations. Four or five items were so well received that it was a delightful experience to present them over and over. For instance, a 50-watt 3-million-cycle oscillator operated a Tesla coil at a power level just below the point of corona discharge. Gas-filled tubes and long fluorescent lamps lit up if held 10 to 15 inches from the coil.

People looked on fascinated as we "squeezed" pink light from one tube, placed it in a pocket, picked up another tube, removed the light from the pocket, and apparently changed its color to blue or red as we threw it into the second tube.

Some people standing close to the stage were delighted when they had the chance to light a 30-inch fluorescent tube in their hands. Others shied away when given the opportunity to hold such a lamp.

The antics of various designs on discs rotated under a stroboscope must have seemed like pure magic to many people in our audiences who could not possibly account for the gyrations in any other way.

The toy train controlled by voice to go forward or backward amused nearly everyone. Despite our most sincere efforts to present facts, we usually had a few skeptics. We quickly appraised each audience before inviting one of their number to try this experiment. Sometimes, when we invited one person on stage, several dozen others insisted that they, too, must try it.

The breaking of a paper disc spinning at 12,000 rpm probably startled these people more than it amused them. But all of them enjoyed audible light. Perhaps it's not too surprising, for this stunt of sending music over a tiny beam of light and interrupting it has entertained millions of people all over the world.

At our 612 shows—we counted them —we played to a conservatively estimated attendance of more than 210,000 people. And on most days, we presented small parts of our show on a television program.

Q: How did the U.S. Government people react to your show?

Gluesing: Surprised and gratified. They assumed that we would daily give 6 to 10 shows. To fill in the gaps in time, the Government men installed a projector and screen for movies. But they promptly removed the movie equipment when they learned that we were willing and able to run stage shows continuously. Then when I heard about New Delhi, I knew that the Government people were pleased.

You see, the original plans for the New Delhi fair called for items from *Adventures in Science* to appear only on television. In late September when people's interest and response to our show in Karachi became evident, the men in charge revised the floor plan for the exhibit portion of the U.S. pavilion in New Delhi. They provided a small stage plus an enclosed audience area accommodating 200 to 300 standees for House of Magic use.

In Karachi I'm sure we could have played to more people had the auditorium been larger. At times the visitors filled our space in three minutes. If they all stayed through a show, it meant that for the next 12 minutes the crowds simply had to pass us by.

Q: Did you have any equipment troubles in Karachi?

Gluesing: Only those brought on by the atmosphere, for the air was hot, humid, and extremely dusty. Although we covered our equipment with cotton cloth each night, next day it would be covered with one thirty-second to one-sixteenth inch of fine dust. This dust-laden air circulated through vents, and once or twice an hour we had to clean the low-voltage contacts of our voice-control train equipment.

Our amplifier ran at high temperatures, and I feared some of the components designed for operation at lower temperatures might fail. Finally, we resorted to fan cooling and had no failures.

My own speaking equipment took the worst beating. With hours of use at fairly high output level, my lungs, bronchial tubes, nose, sinuses, and throat showed signs of wear. I acquired a cough and breathing trouble that took several weeks to shake after the Karachi Fair closed. I blamed this on the dust rather than the weather. For in Karachi the mercury hovered at 100 degrees, several days rising to 104 and 105.

One day I asked a friend if it ever got cool. He said, "Yes, a cold wave is on the way now." Several days later I asked him what happened to the cold wave. "Oh," he said, "didn't you notice? The temperature went down to 90 last night."

Q: Did your crowded schedule leave any time for sightseeing and recreation?

Gluesing: We managed to take a 50-mile trip to the region where the Indus River was flooding highways and road-construction areas. We rode there with a supervisor of a highway construction crew on one of his inspection trips. Our taximan took us to see some hot springs and a crocodile pit.

Another time we went with friends to the Karachi Beach where I had a ride on a camel. The camel came up rear end first, and I almost slid onto its neck. Luckily the front end came up just in time to save me from a fall. When the grunting stopped and the joints straightened, I felt as though I were sitting on a saddle 15 feet above the ground.

One forenoon I accepted an invitation to go fishing. My host hired a good-sized sailboat with a crew of four, and we sailed to the mouth of a large bay. Although we caught mostly small fish, action was fast and the trip an excellent diversion from regular routine.

Q: Now back to the show. When did PIIF close?

Gluesing: On October 15. We packed our equipment that evening, crated it next day, and were off to New Delhi by plane on Monday. Our equipment followed a few days later, also by plane.

Although some exhibits were not fully completed and ready for operation for the first few days, the Indian Industries Fair at New Delhi opened on October 29 as scheduled. More space had been allotted to the Fair, the exhibitors outnumbered the PIIF, and all exhibitors had larger pavilions. I have no figures, but I'm sure the U.S. pavilion was at least three times larger. One portion of it devoted entirely to atomic energy was larger than any single pavilion at Karachi.

Here the show hours were weekdays from around 2 or 3 (depending on weather and attendance) to 10 pm; from 12 noon to 10 pm weekends and holidays—and holidays were numerous. We kept the same length for the show. And one day in 10 hours we actually put on 40 shows.

Instead of hiring readers to recite the script, we hired two bilingual electrical engineers. Within two or three days, they memorized the script, learned how to operate the equipment, and gave shows in English or Hindi entirely on their own. This greatly lightened our own schedules.

Q: I understand that you had some distinguished visitors.

Gluesing: Yes, we did. The agenda, or tour, for all escorted guests listed our show. Most of the special guests visited us in the forenoon—before the public was admitted. For them we gave special unscheduled shows. The visiting dignitaries included several high government officials from both India and Pakistan as well as many from other countries.

Q: Any chance for diversion in New Delhi?

Gluesing: Yes. Upon our arrival in the city, I took one look at the fairgrounds and decided that I could do nothing on the show for at least a week. At the suggestion of Mr. Razdan, manager of the New Delhi IGE office, I took a four-day trip to Simla in the mountains. I'll skip the too numerous details, except to mention the unusual experience of an overnight ride on an Indian railway sleeping car and an eight-hour daylight ride on a narrow-gage railroad that climbed 6000 feet in 60 miles and took me through 102 tunnels and across 750 bridges.

At Simla I enjoyed three days of hiking and climbing on a nearby mountain. Forests of huge evergreen trees and a variety of strange vegetation covered the slopes. And thrilling views of the snow-capped Himalayas stretched out before me in the distance.

Most important to me, however, the air that I breathed deeply while climbing was clean, cool, delightfully fresh, and invigorating. Friends describe the colored stereo pictures that I snapped there as magnificent.

I also took a day's trip to Agra and the Taj Mahal. Although a rather hurried trip, I enjoyed the excellent scenes of rural India enroute. And I marveled at the gorgeous gleaming edifice that is the Taj Mahal. The surrounding handsomely landscaped area makes the perfect setting for this world wonder—a jewel of unrivaled beauty.

While in New Delhi, I rented a bicycle and rode many miles in and around the city during the free hours of the forenoon. Here the streets were wide, clean, and straight. But in Old Delhi they were narrow and crooked, crowded to the point of looking unkempt. In both the old and new, bullocks and bullock carts were as numerous as the camels and their carts in Karachi.

Of the few camels that I saw in a village near Delhi, one such animal hitched to a sweep operated the endless chain of buckets in the village well. Some woven material—probably grass—covered the camel's eyes. Naturally, I asked, "Why the blindfold?" The camel's master was away taking a nap. If the camel could see that his master was not around, he would stop and rest, too. Then the village water supply would also stop. As simple as that.

Time doesn't permit me to tell you about the experience of food in the better restaurants or the interesting hours spent in the fascinating shops. But it was all very wonderful.

Q: When did the Fair in New Delhi close?

Gluesing: According to schedule, it was to close December 15. But on December 5, the Fair organization announced that the Fair would be extended, giving the closing date of December 31. Previous commitments in the United States prevented me from staying to the end. I left Paul Lucey and the two Indian lecturers to bring down the curtain on the House of Magic show.

I flew by Indian Airlines to Bombay where local IGE people put a car and driver at my disposal for several hours of sightseeing on the afternoon of December 13. Then at midnight I boarded an Air India International plane, landed for lunch at Cairo, and dined in Rome the next day. There I changed to a TWA plane and landed at Basel, Switzerland, in time for supper at a downtown restaurant.

Later at Shannon, our next stop, nearly all passengers picked up the maximum importable quota of various liquors. Then on to Gander airport where at 5:30 in the morning I tasted American-type ice cream and cow's milk for the first time since leaving the country four months earlier. At 11 am, December 15, we landed at Idlewild.

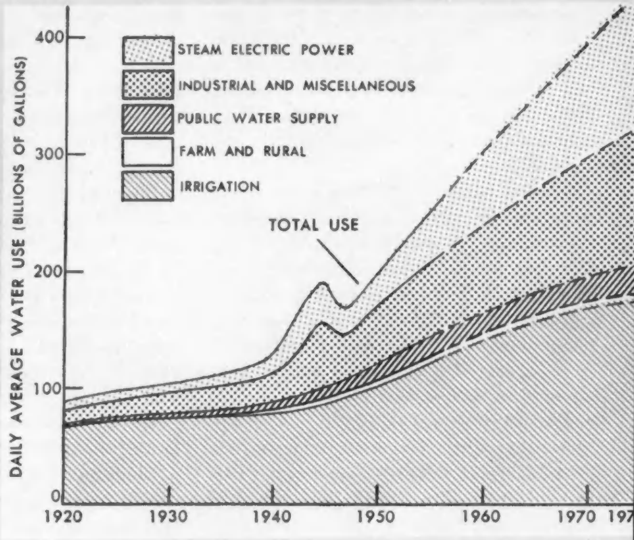
Q: Did it seem good to get back?

Gluesing: I can only repeat what practically every American I've ever met in a foreign country has said, "The States look mighty good to me." —ASA

Since returning from India and Pakistan, Bill Gluesing took the House of Magic show to Osaka, Japan, where he spent a month at Japan's International Trade Fair. He also spent three months touring through Mexico and presenting the House of Magic show at all the large cities in that country. More recently, International General Electric has received invitations for Mr. Gluesing to bring the House of Magic show to Salonika, Greece, and to Argentina. —EDITORS

Industry's Water Needs . . .

. . . as suggested by low-pressure sprays in this mill water basin at one of General Electric's plants . . .



. . . Boost Nation's Consumption

National water use will double in the next two decades, according to the U. S. Department of Commerce.

Water Management Eases Industry's Thirst

By K. S. WATSON and V. deP. LUKAS

America is growing thirsty! The nation's water consumption steadily approaches the maximum recoverable yield of our water resources.

Most Americans mistakenly think water is as abundant as air and sunlight. They are misled by nature's lavish spectacles: the flood, the steady river, the tropical hurricane; and by man-made spectacles: the play of fountains in the park, the boiling froth in the lee of a power dam, and the rush of silver across the dark earth when the pumps release water in a Western cornfield.

Our water supply is *not* inexhaustible. Its absolute usage limit is 1300-billion gallons per day—the amount of the nation's annual rainfall that survives evaporation and transpiration from plant leaves, runs into lakes and rivers, and percolates into the earth.

Though we're using only 16 percent of that maximum amount today, the rate of increase is alarming. By 1975 we'll be using more than double the present amount, nationally consuming an estimated 450-billion gallons per day.

Trouble Spots

Our water resources are not uniformly distributed across the nation. For example, rivers in the North Atlantic States carry 191-billion gallons per day. In an area of equal size—the Red River basin of Minnesota and North Dakota—the river network carries only 4.5-billion gallons per day.

Hence certain areas of the nation are already encountering serious trouble. In Arizona, the average water table has dropped 10 to 15 feet every year since 1941; and nearly 10 years ago that state passed laws prohibiting new well drilling for irrigation purposes. New York City periodically finds it necessary to wage drip-control campaigns, threatening landlords with fines unless they repair leaky faucets within 24 hours. Recent Illinois droughts are the worst on record, with emergency measures taken in 16 major communities. Fully six percent of the public water supplies of the United States, serving more than 1000 communities, are unable to meet peak demands. Oklahoma, suffering its worst drought in 180 years, is becoming a ghost state. Stores are closing; farmers are getting out for their land is blowing away. These areas need more water than nature restores to her reservoirs.

President Eisenhower recently expressed a growing resolve among water experts, when he said: "If we are to continue to expand agriculturally and industrially, we must make the best use of every drop of water which falls on our soil or which can be extracted from the ocean."

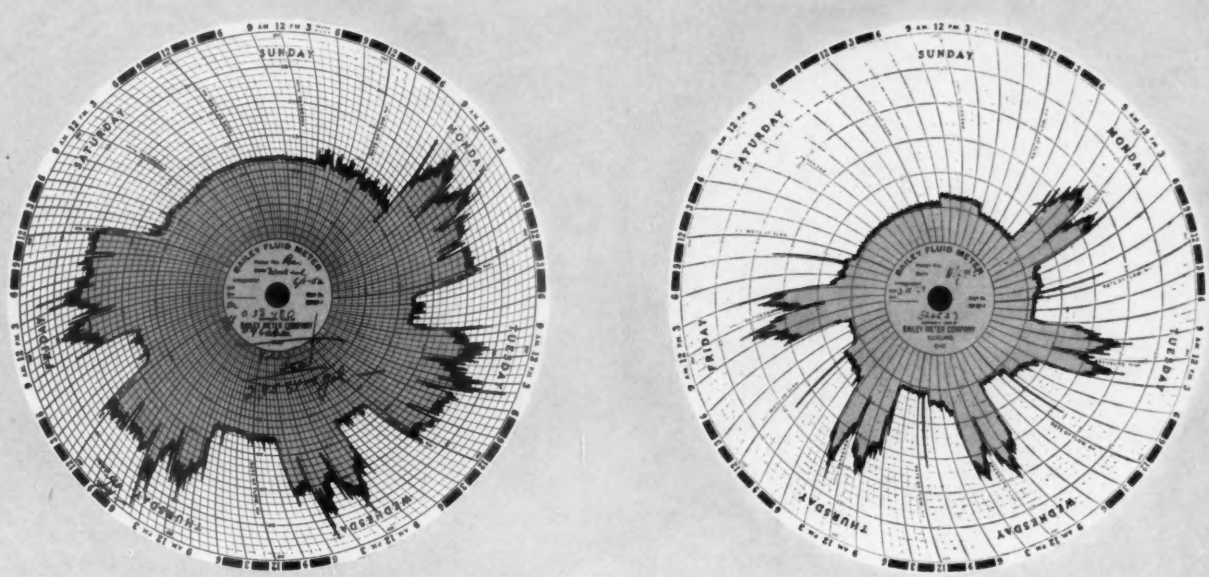
Who Uses Water?

Farmers depending on irrigation are among the hardest hit because irrigation (120-billion gallons per day) consumes the nation's largest amount of water.

Industry ranks second, using 80-billion gallons per day. Manufacturing a ton of average steel demands 65,000 gallons of water. Textiles are prodigious

---

Mr. Watson and Mr. Lukas, both professional engineers and presently with Manufacturing Services, Schenectady, came to General Electric in 1950 and 1953 respectively. Mr. Watson, Consultant, Water Management and Waste Control, supervises a Company-wide program covering the fields of water management. The Secretary of State appointed him Engineer Adviser to the U.S. delegation of the United Nations' World Health Assembly meeting in Geneva, Switzerland, where he participated during May 1956. Mr. Lukas is a Sanitary Engineer providing service, advice and counsel to operating components of the Company in the fields of water management.



Water Use Drops . . .

. . . as it did in General Electric's Electronics Park, Syracuse, NY (color area at left indicates previous consumption; water management techniques produced typical weekly graph at right), when you apply . . .

water users, requiring large quantities in nearly every step of processing. To finish a ton of average cloth requires 140,000 gallons.

The rest of the nation's daily supply—74-billion gallons—goes into steam generation of electric power and directly into residential pipelines. The rising use of dishwashers, two-bath homes, air conditioners, waste disposers, and suburban lawn sprinklers creates new demands on water utilities.

What Industry Is Doing About It

As good neighbors and good citizens in their communities, industrial managers are picking up the tools of water management to reappraise water use in their plants. This goes beyond responsible stewardship of a vital commodity and national resource—it's sound economy if you use much water. Waterworks people traditionally have delivered "cheap water." They have run processing and pumping stations at a deficit and balanced the books by raiding municipal treasuries, maintaining no reserves for depreciation. Today these practices are disappearing. Like the U.S. Post Office, they're looking for a black-ink balance sheet. The magic balancer: Rate increases. Water will become progressively more expensive in the next few years.

The General Electric Company paid $3 million for water last year. And we used much of it efficiently. We're steadily getting better at using water where it

SIX STEPS TO EFFECTIVE WATER MANAGEMENT

This outline covers the major elements of a complete water-management program. In many industrial plants, some of these steps will already have been taken; re-evaluation and modification may then produce an integrated program. The last step, waste treatment—a vital factor in industrial neighborliness—has such complexity that detailed discussion is omitted.

1) Assign someone the responsibility for water management.

2) Use the best source of water available from the standpoint of quantity, quality, and cost.

3) Condition the water for special uses by softening, deionizing, or other conditioning process.

4) Always conserve, recirculate, and reuse water wherever such action is economical.

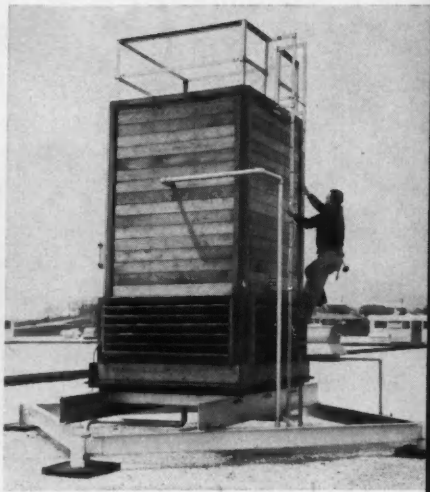
5) Define the plant waste problem and introduce all within-the-plant short-of-treatment steps consistent with economy to correct the problem.

6) Provide waste treatment when the character of the remaining wastes and the receiving stream or sewer require it.

Recirculating Systems

They must justify higher initial cost by recovering large quantities of "used" water in high-volume applications. Basic recirculating units are . . .

Cooling Ponds collect warm, used water and speed evaporation by the use of low-pressure sprays.



Cooling Tower acts as artificial skin for hot industrial work.

counts and shutting it off where it doesn't. And the Company has a proved method of bringing water use under control.

Assign Responsibility

Making someone responsible for water management constitutes our first recommendation in setting up control. Though results depend on teamwork, a well-organized program requires a leader. He may be your plant or facilities engineer, sanitary specialist, or an alert young man in your engineering group. At our large Appliance Park, in Louisville, Ky., a five-man water and waste-disposal team, headed by a supervisor, handles water management.

Choose the Best Source

As the initial item of business, your water specialist must select a source—a step ideally taken when choosing the plant site. In existing plants, a newly appointed water specialist will evaluate streams, lakes, wells, and well-drilling possibilities, comparing them with municipal supplies. He will consider quantity, quality, and cost just as a purchasing agent does in buying other commodities for the plant.

Various waters differ in quality. Well water is usually colder, harder, and more uniform in mineral content than stream or river water. Stream water, though softer, usually carries algae, tastes, and odors.

Conditioning the Supply

After choosing the source best suited to the plant's needs, the water specialist must evaluate the water-conditioning system. Well water, good for drinking, may corrode boilers; stream water, good neither for drinking nor boilers, may be fine for condensing and cooling. Treatment must be tailored for your purposes within economical limits.

Some manufacturing operations demand water of special quality. This may go far beyond the mere softening processes used in many home systems that simply remove certain mineral salts. General Electric television picture tubes are washed with DI (deionized—all minerals removed) water before receiving electrically sensitive interior coatings. Pure DI baths clean germanium rectifier parts in another General Electric plant.

But you wouldn't use DI or even ordinary soft water unless your application demanded it. Usually, you would waste money if you made the entire plant water supply good enough for deluxe use. Duplication of piping and pumps may be a small price to pay to save refined water for the processes actually requiring it. The goal: Use the cheapest water that will do a given job satisfactorily.

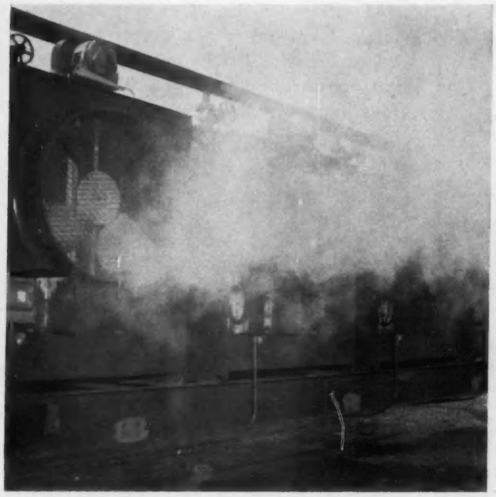
Boiler feed water receives special treatment in most plants. It becomes practically necessary because low-quality water in the boiler system will simply put operating efficiency on the skids. Ultimately, it would damage the equipment itself. But the water supervisor still has his duty here—he should prescribe the necessary internal treatment to protect and safeguard this vital equipment.

Ways of Cutting Volume

A number of conservation steps helps reduce water requirements without any costly investment in special equipment. Meter installations represent one of the simplest and most effective steps. The meter not only provides a graphic record of usage on the particular operation but also shows waste on nights or weekends during the shutdown in operations. Install meters on the main supply and at all high-use points. After your meters are installed, read them. Next, set a realistic use goal and keep everyone on his toes until you hit the goal.

Here's the kind of job meters can do for you: In one of General Electric's Southern plants, meters are already installed at key locations. Records taken from these meters are reviewed by the person in charge of water management. Recently, the records indicated a five percent drop in electric consumption, probably indicating a slight decline in manufacturing operations. At the same time, however, water consumption rose 30 percent. The plant engineer explored a half-dozen possibilities that could cause waste of water. His inspection disclosed a partially opened valve to the mill's water system that could have wasted water at an annual cost of $17,366. Fortunately, by checking the meter readings, this situation was corrected within two months.

Psychology has its place in this kind of work as in so many others. We find that normally frugal employees who always turn off the taps at home often have a different attitude at work. At home, a leaky faucet quickly brings out



Cooling Towers
grouped in package units add flexibility to a system.

Evaporative Condensers
frequently replace water-cooled condensers in up-to-date industrial refrigeration systems.

the do-it-yourself kit. But so much available water exists in some industrial installations that personnel tend toward the attitude of "let 'er run."

We combat this tendency by building water control into some equipment. On an electric welding machine, for instance, there was a psychological barrier to closing the valve to shut off the water supply. It seemed much easier to let it run and then start the machine with a flip of the switch when needed again. Now a simple solenoid valve shuts off the water when the operator flips the electric switch.

A modification of this approach led us to install in the supply lines such water controllers as orifices that limit the amount of available water for the job.

A particularly effective flow-control device utilizes a simple rubber orifice. The size of the orifice and its thickness and seat determine the flow rate at a given pressure. Under minimum inlet pressure of 15 psi, the orifice remains in the normal position. As pressure increases, the flexible orifice varies in size uniformly and inversely in proportion to the pressure. Thus, with the smaller orifice opening at higher pressures, the rate of discharge remains constant.

Our Baltimore plant uses such orifices on a vacuum pump and in pug mills where clay cylinders of various diameters are extruded. Each pug mill formerly used an average of 15 gpm in the water jacket and for bearing cooling. Using a water meter, the manufacturing engineers determined that the pug mills could efficiently operate with a 1-gpm flow at the average city-water temperature. At this low flow rate the temperature increases 4 to 5 F. Allowing for an increase in the water temperature during the summer months, we suggested installing flow-control valves rated at 2 gpm on these units.

The plant engineer purchased and installed the flow-control valves at a total cost of $505 ($165 for material plus $340 for labor). In 1955, water consumption was reduced 75.4-million gallons, at an annual saving of $10,315. Both production and the number of employees increased, yet water consumption was reduced.

Recirculation Techniques

With high water volume, you'll probably want to go beyond some simple conservation techniques (Box, page 40). When you get into recirculation practices, volume savings must justify your investment in equipment. Every plant must be studied to determine whether a central recirculation system or a number of smaller ones provides the most economical answer.

The fundamental concept in recirculation: Retain all clean or cooling water for reuse through the installation of holding, cooling, and pumping facilities. The amount of water consumed then becomes restricted merely to replacing losses in the recirculation system due to wind and evaporation plus the small overflow necessary to keep the mineral content of the recirculating water from reaching too high a concentration. This replacement is 5 to 10 percent of that required in one-pass cooling operations.

In the recirculation of water, cooling is generally accomplished through the use of one of three basic types of installations (photos) . . .

Cooling Pond—A pond that collects all the warm, used water. Pumps spray a portion of the pond water into the air and evaporation reduces water temperature to the desired level. Where increase of temperature is not of great significance, a reservoir or pond without sprays will permit satisfactory recirculation.

In many plants the secondary-groundwater reservoir for fire protection can be made somewhat larger than necessary and used as a cooling pond as well.

Cooling Tower—An artificial skin for hot industrial operations. (The evaporation of perspiration from the skin helps keep our body temperature steady at 98.6 F, though the climate varies widely.)

In most installations, pumps carry water to the top of the cooling tower and it then falls back into the storage basin against a current of air usually forced up through the structure. On other installations the cooling water reservoir stands separated from the tower. The reservoir is placed in the basement of or adjacent to a building with the tower located on the roof. A single tower often cools water from a variety of equipment.

Evaporative Condensers—Widely used in recent years to replace water-cooled condensers. They have a particular application to cooling the condensing coils of refrigeration systems. Far more efficient than water-cooled condensers in conserving water, evaporative condensers should reduce consumption by approximately 98 percent.

The evaporative condenser passes

SOME SIMPLE CONSERVATION PRACTICES . . .

Install additional piping so that a second usage may be obtained from one-pass cooling water.

Countercurrent water in metal-finishing rinse tanks or similar operations so that the same volume of water will be made to work two or three times.

Substitute spray for running rinses on cleaning operations. Another rinsing refinement includes an agitator and siphon breaker in the line supplying the flowing rinse tank.

Use temperature-control devices that increase or decrease the flow of water depending on the temperature of the equipment being cooled. Such devices may also be used in recirculation systems. It's hard to regulate cooling water flow with a hand throttle. For safety the throttle is usually set too wide. Thermostatic control will do the job automatically on air compressors, molding machines, and other process equipment requiring cooling water. In addition to saving water, you obtain better performance and efficiency on the equipment.

If you must use running rinses, don't permit open-end hoses in washing and rinsing operations. There's a tendency to throw them aside without shutting off the water when not needed. Use spring-type valves that close when not in use.

Regulate water pressure in the piping system. High pressures cause waste. Install pressure regulators to reduce and regulate rate of flow.

Keep heat-exchange equipment clean and free of scale. This should be included in a preventative maintenance program. Improved heat-transfer reduces water requirements substantially.

Check all types of sanitary fixtures for waste. Put spring valves on all drinking fountains. This presents a problem not on water coolers but on many of the older type fountains. Adjust the flow on toilet valves. Some run for one minute; 7 to 11 seconds are sufficient. Hand-control urinal flush valves are best. Some plants use automatic systems. These should be checked frequently and adjusted to the minimum that maintains sanitary conditions. Provide convenient shut-offs for automatic systems, especially during nonworking hours.

heat of a refrigeration installation, air conditioning unit, or cold box in the factory from a circulating refrigerant in condensing coils to recirculating water sprayed over the coils. An air-cooling section in the condenser transfers the heat to the air by evaporation. These condensers may be placed either indoors or outdoors.

Results of Water Management

When you have taken the basic steps toward effective water management—assign the responsibility, pick the best source, condition the water according to need, conserve, and use recirculation techniques to spot and stop waste—you will begin to see the results roll in. First, if your community numbers among those suffering from shortages, municipal officials may extend their compliments for the plant's good citizenship in reducing its needs. Second, you'll begin to realize appreciable dollar savings.

General Electric began its program in 1950. Without the water-management function we would be using an additional 5-billion gallons of water annually, adding about $1.7 million to our water bill. This represents a conservative figure since savings from the program in many of our plants have not yet been evaluated.

You begin to pay attention even to seemingly small items in the effort to further increase savings. A dripping faucet seems a minor item until you learn that a ⅛-inch drip at the usual 40-pound pressure wastes 76,900 gallons per month. You learn to catch rain water, too. We're creating a little lake at one of our General Electric locations to catch rain water run-off on our property. After it settles, we'll pump it to the 4-million-gallon reservoir that supplies the mill water system.

But our water consumption still rises. Curiously enough, a nonproductive factor—landscaping—acts as one of the strong forces behind the rise. We like to have our plant sites appear attractive for community friends and neighbors, as well as to provide a cheerful atmosphere for employees. More and more landscaping requires more and more water. At Louisville, we have nearly 1000 acres in lawn. At Electronics Park in Syracuse, green grass makes up 60 percent of our property, and that takes a lot of water.

Cost Experience

One of the most interesting results of our work to date comes in the area of water costs. Generally, we can develop our own private water sources at a much lower cost than we can buy water from municipalities.

About half the Company's water comes from nonpublic sources at an average cost of 3.7 cents per 1000 gallons for well water and 3.9 cents for chlorinated stream water. City water of the same quality costs from 13 to 26 cents; municipal rate increases average a half cent per year.

Our experience with recirculation lends financial impetus to that practice: recirculated water costs an average of 3.6 cents per 1000 gallons. That figure includes five-year depreciation allowances for the cooling and associated equipment presently in operation in our 15 recirculating plants. Those plants are saving $368,000 annually by recirculation alone.

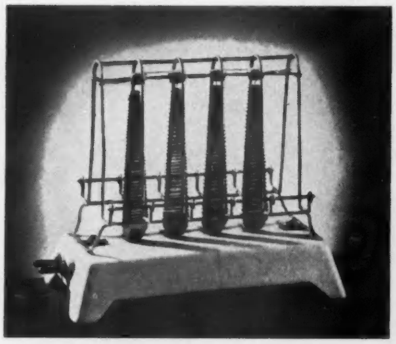
At General Electric's Syracuse plant, water management has yielded very effective financial results. The 68 evaporative condensers installed at the time the plant was built save 415-million gallons per year. Water consumption dropped 648-million gallons per year, saving $100,000 annually after water-management techniques went into effect.

Production has risen at Electronics Park by about 25 percent since 1951, a year in which 490-million gallons were required. In spite of the production increase, only 398-million gallons were used in 1953, a saving that conclusively demonstrates the benefits of the water-management program.

Next Step Forward

You will note that all of the steps in water management as outlined here fall short of using waste treatment and sewage facilities. Disposal of wastes supplies an important part of water management. A point to remember: Regardless of the nature of discharge from your plant's operations, its total quantity will be substantially lessened by sound water-management principles. If you don't waste water during manufacturing, you won't have an excessive volume at the end of the process when you're ready to dispose of effluent.

Water management can pay the same kind of dividends for your plant. Our techniques, developed in the last few years, must become still better if we are to achieve the great potential savings that still remain. Let's never forget that even at the lowest price, wasted water is a costly drain on our communities. Next year, or the year after, the nation's growing thirst may show up in shortages in *your* plant city. Make sure your operation is doing its utmost to use no more than its minimum share of the supply. Ω



A marked change has occurred in toaster styling and mechanics since 1908. At this time, General Electric's first model (above) consisted of only the barest essentials. The new Toast-R-Oven gives today's housewife style and beauty plus a more practical and advanced product.

Something New on the American Breakfast Scene

Behind the development of this modern appliance, you'll find industrial designers, engineers, and manufacturing personnel working as a team.

By PAUL O. RAWSON

Every morning when your wife drops a slice of bread in the toaster and presses the lever down, she sets in motion one of the most highly refined products on the American breakfast scene. On the market since the 1900's, a toaster operates on three out of every four breakfast tables in today's electrically wired homes. More than 34 million are in use —ranking second in popularity to the hand iron—and retail sales topped $56 million during 1955 when sales reached 3,350,000.

But for the past several years, toaster styling had gone stale. Yes, progress had been made since 1908 when the first General Electric model consisted of the barest essentials—simple wire-formed bread racks and heating-element supports on a ceramic base (photo, left). In those days, burn and short-circuit hazards or an even toasting pattern received little consideration.

In 1939, General Electric produced a pop-up toaster—an innovation making it a more nearly automatic appliance. But from the early 30's to the present, the conventional slotted "chicklet" form prevailed. The manufacturers simply juggled the basic features common to most designs, sometimes combining them in various ways. While the mechanism had been constantly improved, costs reduced, and operational efficiency reached a high degree, still the appearance and the function remained static.

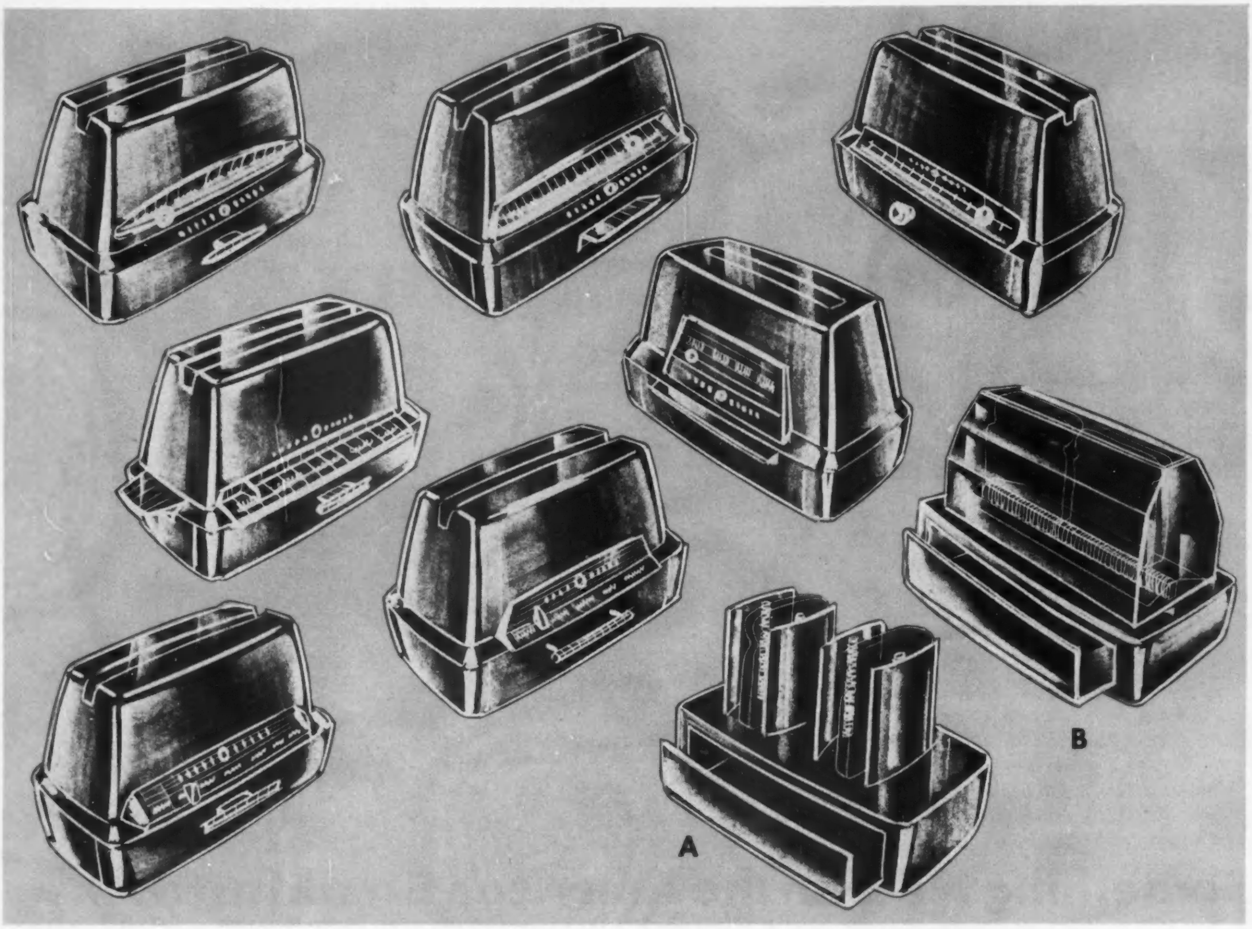
Something Better

Early in 1953, management of General Electric's Portable Appliance Department called together its key people to search for a new toaster concept.

Market research reports proved valuable background. Over a period of years, data had been compiled regarding the advantages and disadvantages of existing toasters. To this was added the analyses of depth interviews conducted by our advertising agency.

One problem outranked all others: frustrated hot-toast fanciers wanted some built-in provision for keeping toast warm. The objective: Answer the need for something better than the present appliance. Although no strict ground rules were spelled out, we agreed that the new product should have an open compartment, power-driven toast carriage, new appearance, and a competitive price.

Mr. Rawson—Designer-In-Charge, Portable Appliances, Housewares and Radio Receiver Division—has had broad experience in industrial design since joining General Electric in 1945. Presently he is concerned with finding the best industrial design solution for such appliances as toasters, mixers, and skillets plus the development of new products.



SKETCHES were constantly being adjusted as the industrial designers worked along with the engineers from change to change.

As a coordinated team, industrial designers, engineers, and manufacturing personnel moved in on the project. Industrial designers felt that the appearance of the final product must express the fine engineering and the use value to the prospective purchaser. They wanted new functions and features that would allow for excitingly new physical proportions and characteristics. The proposed oven compartment—to keep toast and pastry warm and to make open-face sandwiches—was the answer.

Fundamentals in Engineering . . .

Theoretically, you might think of a toaster with a built-in oven unit as a conventional two-slotted toaster superimposed upon a horizontal heating unit located over an oven chamber. It seemed important to depart from the conventional mica heater elements—mica sheets wound with electric resistance wire—because of their high cost and unsightly appearance.

Another engineering aim involved reducing duplication of component parts in such a scheme.

In one of the first of a great many operating "breadboard" samples designed and built by General Electric engineers, duplication was minimized. Two resistance-wire-wound rods were positioned beneath two side-by-side vertical toasting compartments; their walls reflected the rod's radiation evenly over the bread surfaces (illustration A). Although the combination of direct and reflected radiation might have offered certain advantages, full reflection was dictated in the ultimate design—and for a good reason. Over a period of time the surface of the reflectors involved in this early sample might fall off slightly in efficiency, but the directly radiated heat would not. Result: Uneven browning of the toast.

At first, arrangement of component parts seemed practical, but one of the working samples later created by engineering provided many more advantages, eventually deciding the final functional approach. The new arrangement placed the toasting compartments end to end (illustration B), reducing the four heating units of the original concept to a single longitudinal wire-wound rod. The heating elements not only toasted the bread but also kept the contents of the oven warm—a feat accomplished by focusing the heat of the elements into the oven simply by operating a set of movable flipper reflectors.

The fabrication of the toasting compartment reflector was also simplified: the two side-by-side toasting units became a single unit that, because of its fewer joints and fastenings, contributed to greater strength and economy. The pleasing physical proportions of the length to the width and height of this engineering sample in contrast to the blocky appearance of the previous samples offered another advantage to the industrial designers.

DESIGNING THE TOASTER MECHANISM

This extract was taken from a report by W. A. Schmall, Project Development Engineer:

Numerous power-driven carriage schemes were considered before we adopted the expansible-ribbon drive. In operation, the expansible ribbons pull against a carriage spring. Linkages are connected to the carriage spring. The ribbons expand when energized, permitting the carriage spring to raise the carriage and the toast to the upper position. At this position, the carriage latches up and the ribbons de-energize. Cooling and contraction of the ribbons extend the carriage spring again. Releasing the carriage latch initiates the next operation. This permits the carriage to drop by gravity.

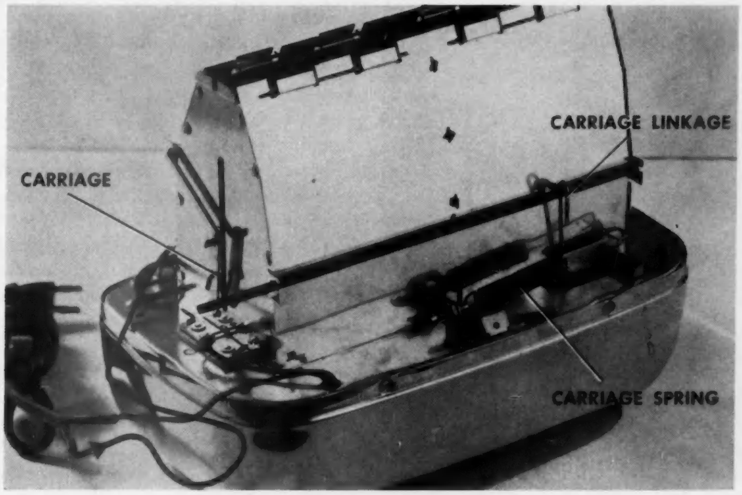
Special care taken in the design of the linkages provides variable multiplication, depending on carriage position, allowing the stress in the nickel-chrome-alloy ribbons to approximate the yield-strength curve of the material. That is, the ribbons are stressed higher in a cold condition than when heated.

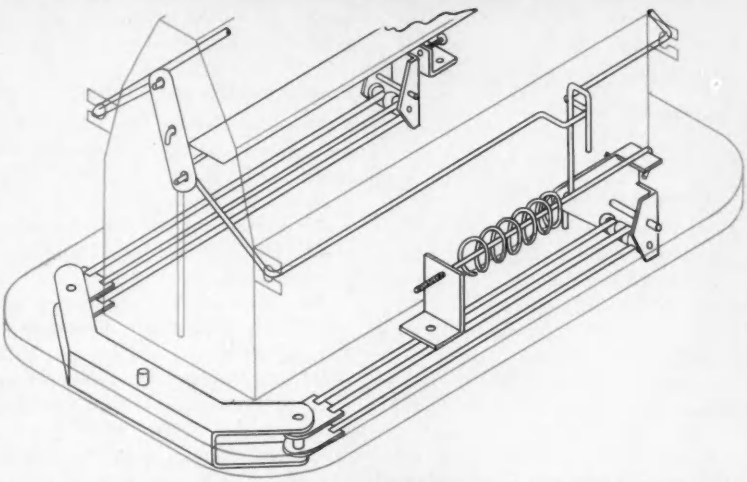
After studying several ways to provide toast-color sensing elements for the toast and oven compartments, we decided to use a thermal timer similar to the one in the present toaster. The big advantages of the timer: It controlled both the toast and oven operation; and it permitted a simplified control mechanism, from the standpoint of design and for the user.

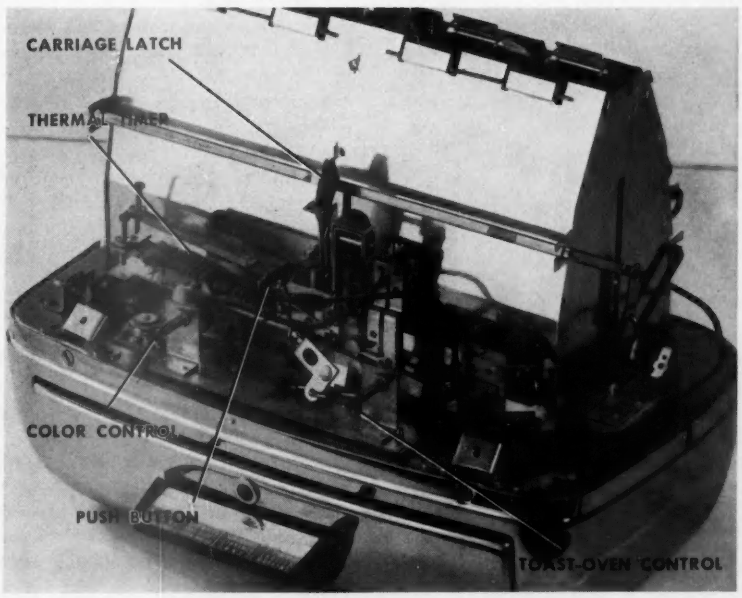
Oven warming is accomplished by the use of a unique flasher that cycles the heater on and off. The flasher consists of three small bimetallic pieces and two contacts. The heater cycles several times before reaching oven temperature. This prevents any browning or cooking of articles placed in the oven for warming. The design also provides for a slower cycling rate, eliminating objectionable radio noises.

To understand how the appliance operates, let's assume you want to make toast. Place the bread in the slot, move the right-hand control to TOAST, turn the color control to the desired degree, and then push a button to start the cycle. Operating the push button drops the carriage and energizes the heater. When the toasting period is completed, the timer allows the heater contacts to open and the drive contacts to close. The drive ribbons are energized; their expansion permits the carriage spring to pull the carriage back to the upper position. When it reaches the upper position, the drive contacts open and the carriage is latched in the upper position.

To perform an oven operation, you place the item in the oven, move the control to OVEN, move the color control to the desired degree, and again start the cycle by pushing the button. The oven operation is then automatically controlled in the same way as the toasting operation. To perform the oven-warming operation, merely move the color control to OVEN WARM. The heater will now cycle until the push button is raised, terminating the cycle. Press down on the push button to start all operations; when lifted, the push button will interrupt all operations.







MODELMAKERS apply plasticene to clearance skeleton while Rawson (center) watches.

. . . Designing . . .

Now that the functional and economic factors were shaping up, industrial designers recognized a long-awaited break towards the good appearance aspects.

Up to this point, they had been working along with the engineers from change to change, constantly sketching and sculpturing three-dimensional clay models around the current engineering developments. The end-to-end arrangement had such merit that a final concentrated effort began, following the usual procedures for similar appliances such as coffeemakers, skillets, and irons.

A task force of several industrial designers began searching—employing a multitude of pencil sketches—for a strong styling theme. The best way to make the shell components and controls from both an aesthetic and practical point of view was an important consideration. The next step: Have four or five designs—composites of all the best characteristics developed—sculptured to exact size in plasticene over engineering's clearance skeleton (photo). The skeleton showed not only all stationary parts of the enclosed mechanism but also clearance for motions described by moving parts.

. . . and Manufacturing

Using these highly accurate three-dimensional models, manufacturing engineers gave full attention to the solution of the manufacturing problems involved in the various design parts. Forming and polishing of shells in production required certain minimum radii, generated surfaces in a vertical plane, and allowance for blanking from strip material of an available width.

Plastics components—molded of thermosetting phenolic material needed for its heat-resistant characteristics—were designed to provide sufficient gripping surfaces and protection against burned fingers. At the same time, industrial designers fashioned control knobs and push-button controls that operated easily. Full-color drawings further described the design details with respect to color and finishes, particularly in the control area.

With the fundamentals of the toaster settled, engineering advanced the development of the toaster mechanism (Box, page 43).

Smoothing Out the Snags

The project had its quota of snags. The unusually long development period indicates the many problems and limitations. In the production area alone, for many months the forming of the upper shell defied the best thinking of experts in metal forming.

The necessity of including a center baffle in the toasting compartment also caused engineering a serious setback. Needed to accommodate toasting a single slice of standard-size bread without undue browning of the bread adjacent to the vacant compartment, the addition of this center baffle meant that the toasting compartment had to be either higher or longer to accommodate the larger standard bread slices.

Industrial Design moved in on the problem, deciding to go higher to achieve the best visual proportions and keep to a minimum the table surface required by the appliance. Engineers then developed new reflector shapes—a major undertaking.

Directional Design

The appliance's final appearance presented a stimulating challenge. Conviction was strong that the toaster, as in most similar products, should have directional design—a pronounced and recognizable front and back. Previous designs fell short because, almost without exception, the emphasis and center of interest was divided between a handle and controls on one end and a purposefully symmetrized handle and details on the other end. New design features were needed to help our professional advertising associates better dramatize the product in their advertising and sales promotion programs.

Grouping the controls and drawer emergence (handle and temperature chart) on one of the major surfaces of the relatively rectangular mass accomplished this directional design. Though chosen for aesthetic reasons, the major surface selected happily turned out to be the placing that allowed the most satisfactory use on most dining tables and snack bars—especially when the toaster was backed up to an adjacent wall. The unsymmetrical over-all design of the shells further emphasized the front-and-back illusion. Plastics handles, once considered for placement in the conventional end locations, were placed front and back to help heighten the effect. This placement had another benefit: it reduces the over-all long dimension, an important consideration for both packaging and storing. The oven handle also doubles as a lifting handle, eliminating one of the plastics components found in many conventional arrangements.

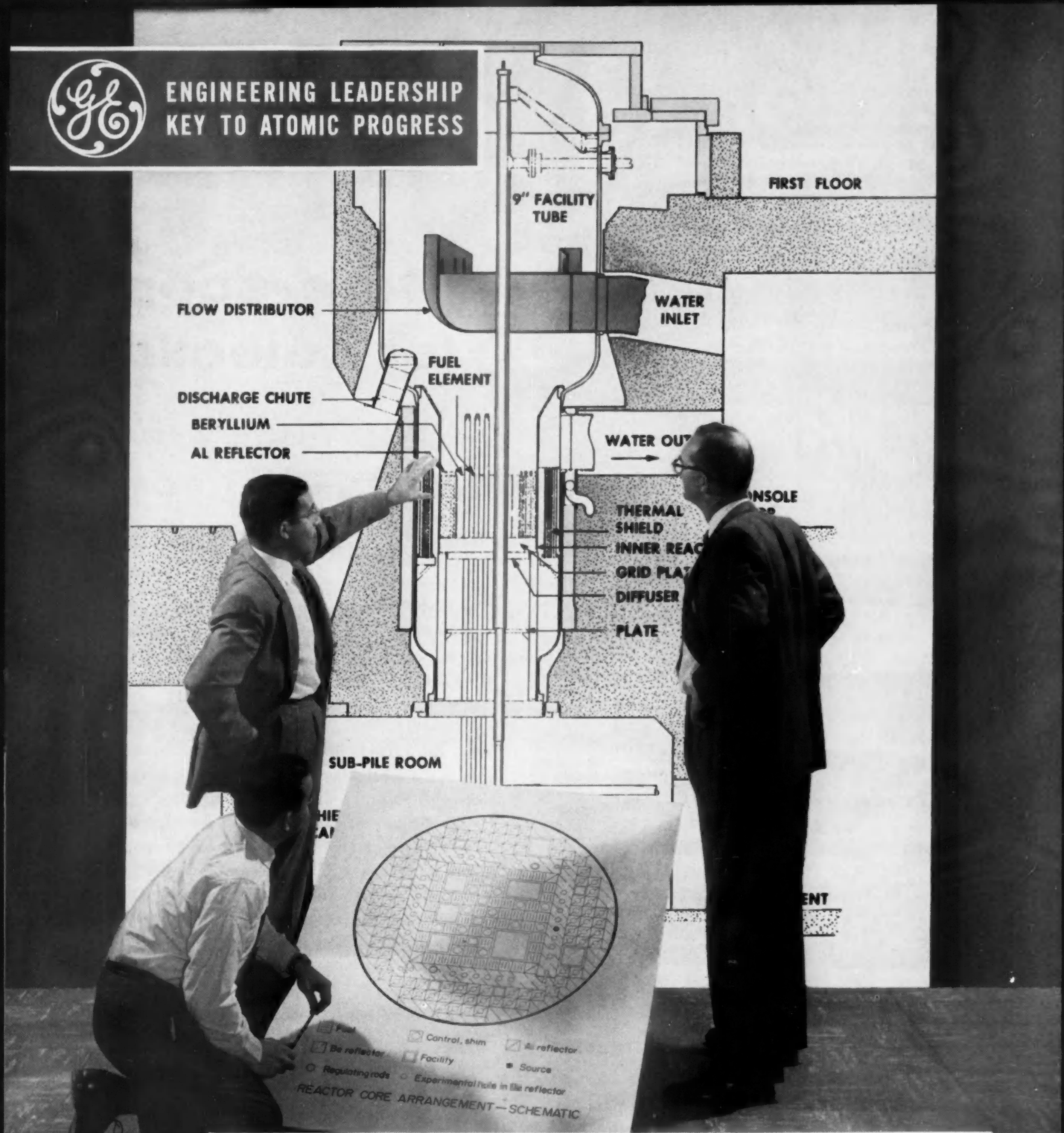
On the Market

Launched at the National Housewares Show, July 1956, the new product has gained market acceptance; it gives the housewife what she asked for at a price only a few dollars higher than an ovenless model. And from a functional and styling viewpoint, she's getting a product that's a leader.

The teamwork between marketing, engineering, manufacturing, management, and industrial design has paid off once again. Ω

CREDITS

Page	Source
Cover	George Burns
13 (top right)	Boeing Airplane Co.
27 (top left)	Randazzo and Morrison Kansas City, Mo.
(top right)	Ryan Aeronautical Co. San Diego, Calif.
(lower left, 2)	Linde Air Products Co. New York City
33 (lower left)	Pix Incorporated New York City



General Electric engineers design 175,000-kw Engineering Test Reactor

A test reactor with extremely high flux, coupled with in-core testing facilities, presents heat transfer, physics and mechanical problems of a new magnitude. In designing the Engineering Test Reactor, General Electric engineers provided solutions to these difficult problems.

This reactor was designed by General Electric for Kaiser Engineers, prime contractor to the AEC, and will be placed in operation at the National Reactor Testing Station, Idaho.

The accomplishment of this design is another example of General Electric engineering leadership in the field of atomic energy. Atomic Power Equipment Department, General Electric Company, San Jose, California. 196-4

Progress Is Our Most Important Product

GENERAL ELECTRIC

More scope for selection

IN THE FULL LINE OF GENERAL ELECTRIC CABLES

The General Electric line of hundreds of wires, cables, and cords covers just about every possible need. Typical of these are flame-resistant, heat-, moisture-, and weather-resistant types and special constructions to withstand vibration, the electrostatic effects of adjacent power cables —even the effects of atomic radiation. Thus, G-E engineers can suggest the most efficient and economical solution for a particular situation and are never limited to one cable, cord, or wire for a given job.

This is one of the important reasons why General Electric wire and cable engineers have been able to help many industries with their electrical expansion and modernization plans. Another reason is General Electric's knowledge of the requirements of other basic components of power distribution systems — transformers, load centers, switch-gear, etc.—and the importance the right wire or cable plays in satisfactory system performance.

All this adds up to experience . . . the kind that can benefit you. Next time you have a cable selection problem it will pay to take advantage of General Electric's knowledge and experience.

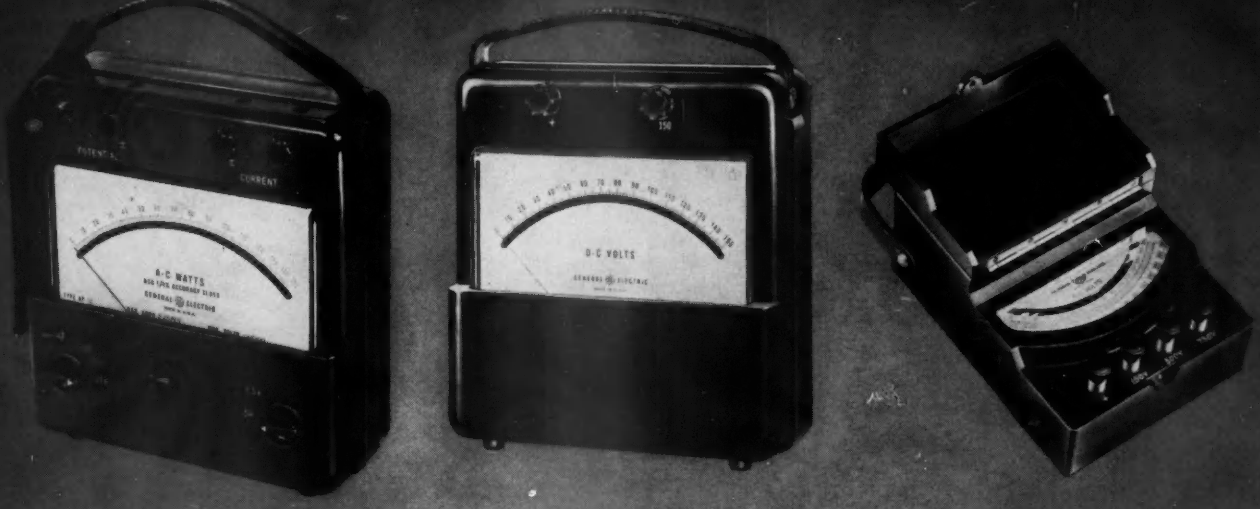
For information on your specific wire and cable application or selection problem see the G-E wire and cable specialist in your locality or write to Section W192-1137, Construction Materials Division, General Electric Company, Bridgeport 2, Connecticut.

*Registered Trade-mark General Electric Company

Progress Is Our Most Important Product

GENERAL ELECTRIC

Instruments for Precision Measurement



AP-12	DP-12
For a-c/d-c measurements	For d-c measurements
Accuracy: ¼ of 1% of full scale	**Accuracy:** ¼ of 1% of full scale

Scale length: 5.5 inches
Size: 7¾ x 7⅞ x 3¼
Weight: 5 lbs

AP-11	DP-11
For a-c measurements	For d-c measurements
Accuracy: ½ of 1% of full scale	**Accuracy:** ½ of 1% of full scale

Scale length: 5.5 inches
Size: 7¾ x 7⅞ x 3¼
Weight: 5 lbs

DP-9	AP-9
For d-c measurements	For a-c measurements
Accuracy: ½ of 1% of full scale	**Accuracy:** ¾ of 1% of full scale

Scale length: 4.1 inches
Size: $2\frac{7}{16}$ x $6\frac{9}{16}$ x $4\frac{13}{16}$
Weight: 2½ lbs

Now, a Complete Line of General Electric Portables to Meet Your Specific Needs at Lower Cost

From General Electric's newly expanded line, there is a portable instrument specifically designed for your testing job. Now, you can choose a portable testing instrument that combines G-E quality and dependability with your special requirements for accuracy, range, type of measurement, and price.

NEWEST ADDITIONS to the General Electric line are the Type AP-12 high-accuracy a-c/d-c portable ammeters, voltmeters, and wattmeters which match the Type DP-12 high-accuracy d-c portables. Both have an accuracy of ¼ of 1 % of full scale.

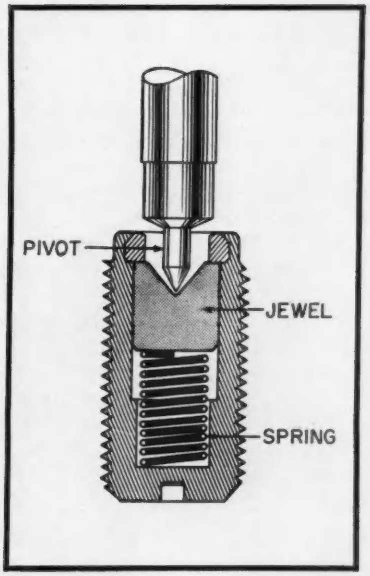
FOR A-C MEASUREMENTS where only ½ of 1% of full-scale accuracy is needed, you now can purchase G.E.'s new Type AP-11 portable. For d-c measurements with this accuracy, G.E. will continue to offer the Type DP-11 instrument. Rounding out the line are the low-cost Types AP-9 and DP-9.

LONG, EASY-READING SCALE, knife-edge pointer and mirror, spring-mounted bearings, improved shielding, and break-resistant Textolite* case are some of the G-E features which give you portable testing instruments with the rugged dependability demanded of plant test equipment and the performance characteristics generally associated only with higher priced laboratory standards.

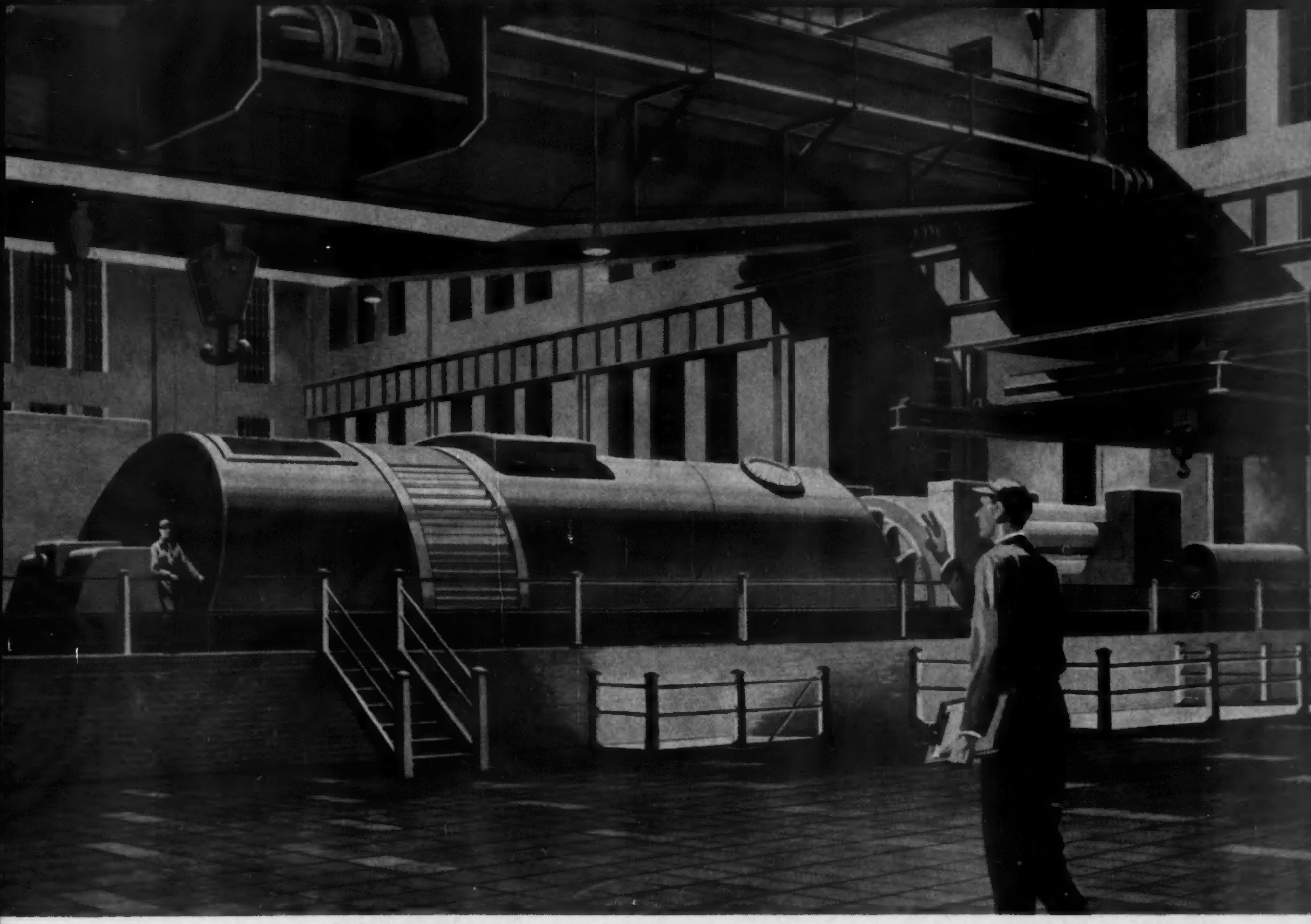
FOR MORE INFORMATION, contact your nearest G-E Apparatus Sales Office or write for bulletins to: General Electric Co., Section 582-21, Schenectady 5, N.Y.

UNIQUE PIVOT-AND-BEARING DESIGN, shown at right, gives longer life to all G-E portable instruments. Spring-mounted jewels cushion the pressure on pivot points to minimize the danger of damaged pivots and jewel assemblies, a major maintenance problem with most portable instruments. →

**Reg. trade-mark General Electric Co.*



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

Progress Is Our Most Important Product

GENERAL ELECTRIC