GENERAL ELECTRIC Review

MAY–JULY 1956

Dr. John C. Fisher joined General Electric Research Laboratory in 1947, right after receiving his *Doctor of Science* degree in Mechanical Engineering from M.I.T. Today he is manager of the *Physical Metallurgy Section*. In addition to Dr. Fisher's interest in mechanical properties, his work at G.E. includes investigations of the magnetic and electrical properties of metals and ceramics.

Secrets of alloy strength

General Electric's Dr. John C. Fisher discovers how atomic order influences ability of alloys to resist deformation under load

One important factor in the strength of alloys is the local arrangement of the different kinds of atoms in them. Large atoms tend to pair off with small ones, because they fit into the alloy crystals better that way. Dr. John C. Fisher of the General Electric Research Laboratory has shown that this type of structure exhibits greater resistance to deformation than pure metals, in which the atoms are all of the same size.

According to this concept, plastic deformation separates some of the atomic pairs, and their resistance to separation causes the strength. It is now known that many alloys of commercial importance owe their strength, at least in part, to this cause. Thus the study of solid-state physics, directed toward understanding the strength — as well as electrical and magnetic properties — of metals and alloys, is today laying the groundwork for the development of new materials to meet the needs of the times.

• • •

As General Electric sees it, providing individual scientists with freedom and incentive to solve the problems of research is part of solving the larger problem of how we can all live better, with better materials and better products with which to work, better jobs, and extra human satisfactions in terms of what people expect and want in life.

Progress Is Our Most Important Product

GENERAL ELECTRIC

MAY–JULY 1956 • VOLUME 59 • NUMBER 3–4

GENERAL ELECTRIC Review

EVERETT S. LEE • EDITOR PAUL R. HEINMILLER • MANAGING EDITOR

COVER—Typical of regional shopping centers all over the nation, the pleasant and colorful Cross Country captures the imagination and pocketbook of suburbanites in Yonkers, NY. Lighting effects used in these modern-day market places are planned for both attraction and attractiveness. For details, see page 8. (Photo courtesy of *Light*, Lamp Division, General Electric, Nela Park, Cleveland, Ohio).

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 CONTENTS OF THE GENERAL ELECTRIC REVIEW ARE ANALYZED AND INDEXED BY THE INDUSTRIAL ARTS INDEX, THE ENGINEERING INDEX, AND SCIENCE ABSTRACTS. . . . 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.

General Electric offers new single-cycle BWR* for atomic power plants

Designed specifically to furnish energy for electric power generation

Forerunner of a whole new family of small power reactors, the General Electric single-cycle boiling water reactor is a new source of energy designed for power plants in a range of 5000 to 20,000 kw. It can be modified for larger ratings.

Boiling in the reactor itself and forced circulation offer these advantages:
(1) Simplified design; no main heat exchanger used. **(2)** High thermal efficiency. **(3)** Automatic control of response to load changes. **(4)** Greater safety since reactor is self-limiting in case of excessive nuclear reactivity.

This reactor uses fuel elements of the long-burnup type. Spent fuel elements are stored in the service pool adjacent to the reactor until cool enough for futher handling.

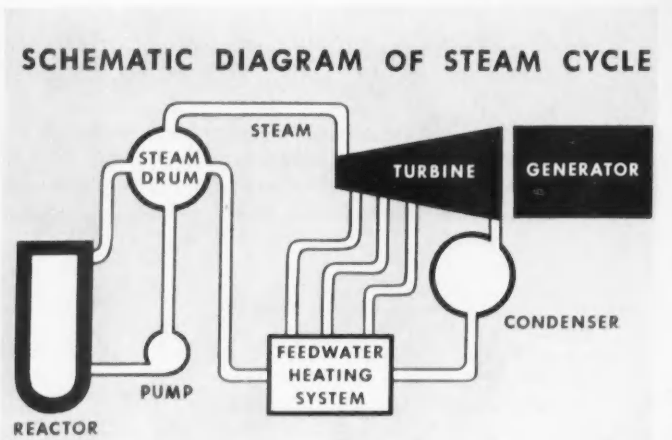
The reactor and service pool can be equipped for neutron and gamma irradiation for research without interfering with reactor operation.

For more information, write for bulletin GER-1220, Sect. 192-7, or contact the Atomic Power Equipment Dept., General Electric Co., Schenectady 5, N. Y.

**Boiling Water Reactor*

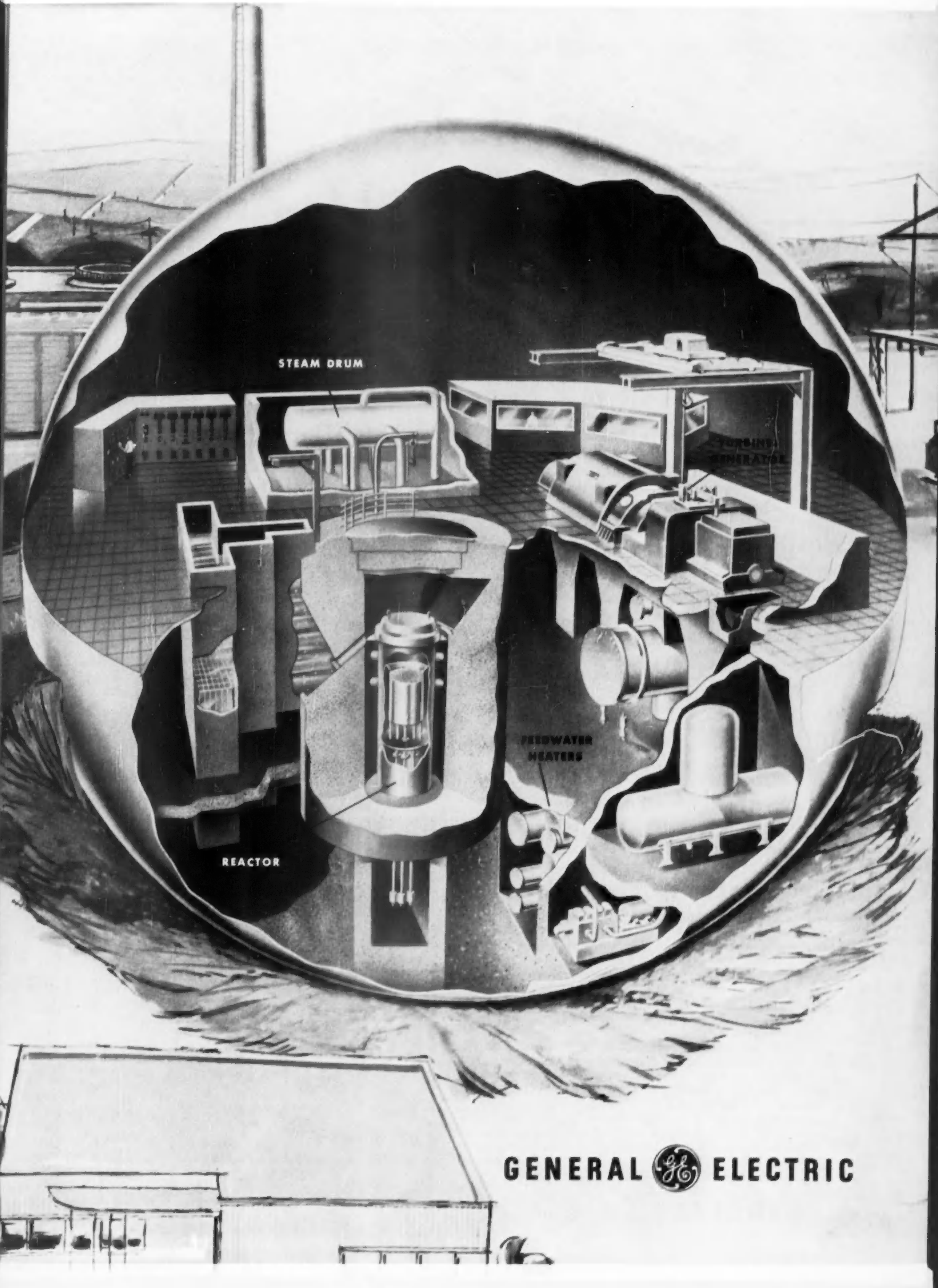
Progress Is Our Most Important Product

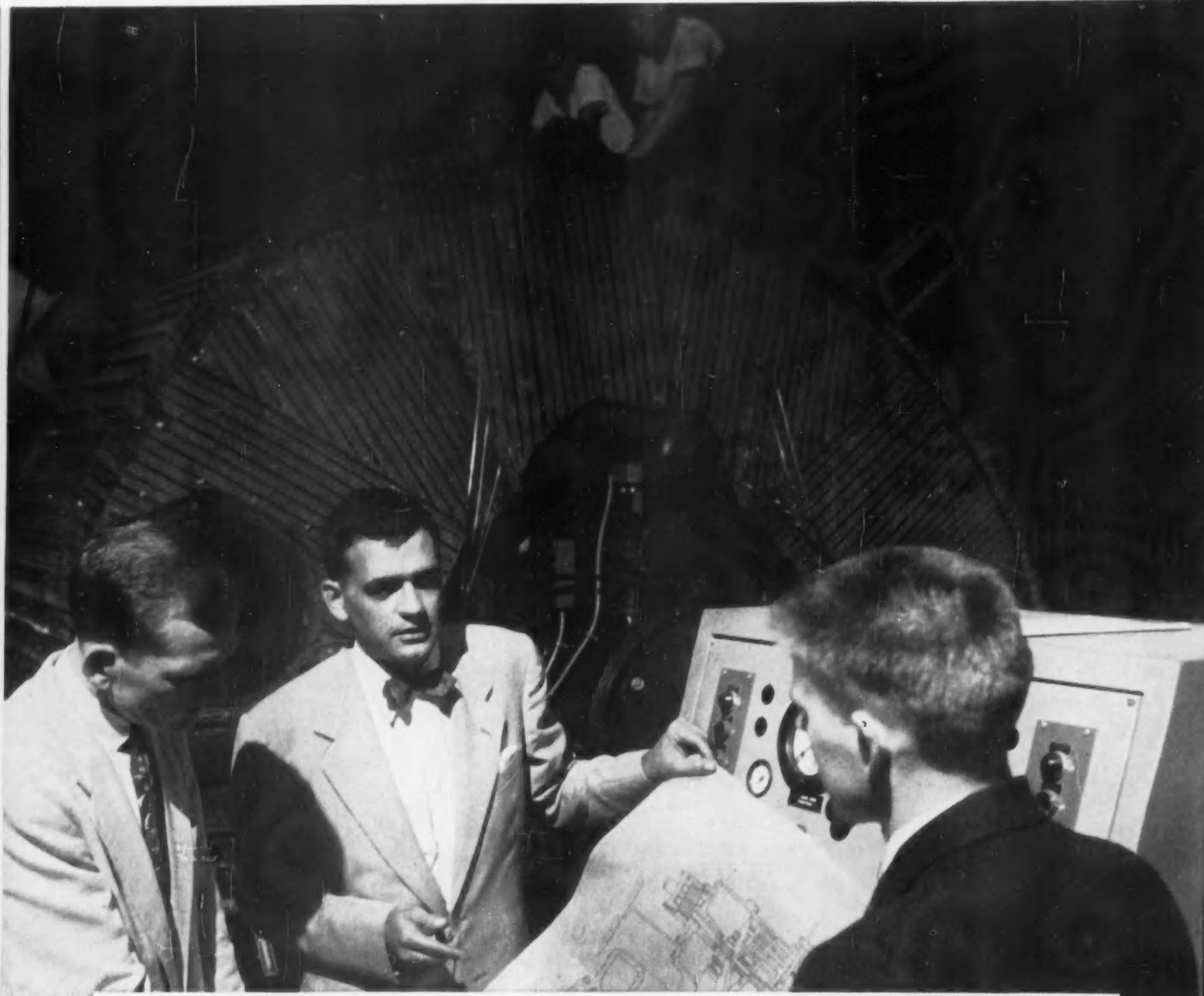
GENERAL ELECTRIC



SIMULATED FUEL ELEMENT being installed in a heat transfer loop for tests under reactor thermal conditions. This is one of G.E.'s supporting atomic development programs to advance reactor design.

STEAM FLOWS FROM REACTOR to drum. Saturated steam passes to turbine; water goes to feedwater heaters and returns to steam drum. Forced circulation pump provides automatic control of response to load changes.


STEAM DRUM
TURBINE-GENERATOR
FEEDWATER HEATERS
REACTOR
GENERAL ELECTRIC



GREAT CAUSES

Our country has been built on great causes. We see Washington at Valley Forge in the cause of freedom. We hear Lincoln at Gettysburg in the cause of government of the people, by the people, and for the people.

Each man can make his own life a great cause. As he thinks, and plans, and works, he can bring into being that which he, and he alone, can contribute to the common good. And the net result is something new—progress.

The power of all of this is tremendous. Yet it emanates from an inner urge which each man has and which he converts into action. Thus our leaders emerge; thus great causes crystallize.

Today the engineering profession sees the crystallization of a great cause. There is a shortage of engineers, of scientists, of teachers.

Voices from everywhere are being raised. Conferences everywhere are being held. Plans are being submitted. Legislation is being considered. The press is filled with the subject. Great minds are at work.

This is all for great good. But to the individual engineer the opportunity can be a great obligation. If each engineer in his own community would seek out a youth in high school—or even in junior high school—and would bring to that boy the story of engineering and of science, we would be assured that large numbers of our young people would hear our message. They would learn something of the great engineering profession, of what engineers have done to make our country great, and of the needs for maintaining that greatness. Who is better qualified to tell the story, to encourage the youth, to guide him, and to counsel him than the engineer?

Such individual participation leads, in turn, to group participation in the community. Here broader problems come to light. Are the schools adequate in teachers? In curricula? In facilities? In guidance? Do all of them provide a substantial progression from the high school to the engineering college? Wherever there are barriers to this progression, the analysis of the situation and the planning and action with the responsible community groups can become a contribution which cannot be made as well in any other way.

Although education has been in the past largely a community responsibility, state aid is becoming more prominent, and now federal aid is being brought into the picture. Plans specifically for engineering and science education, and for teacher increase, are coming from everywhere. The participation of the engineer in community affairs thus allows him to provide advancement both from his own initiative and from his assessment and evaluation of the plans proposed by others together with any legislation that may ensue.

This is a cause to which many engineers have given time and ability in the past and are giving at present. They do this both as individuals in their community and through group participation in community, state, and national affairs. But infinitely more is needed. It is a responsibility for each and every engineer to undertake for himself.

It is a universal problem. It is an obligation responsibility. It is a grass-roots opportunity. It is a great cause.

Everett S. Lee

EDITOR

PARKING LOTS are well illuminated by tall top-decorated poles that help to create dramatic effects.

STORE FRONTS increase their attraction power with continuous bands of translucent plastics.

ALONG THE MALL landscaping, landscape lighting, and decorative elements charm shoppers.

IN DETROIT'S NORTHLAND, LIGHTING—A MODERN

How We Design L

The more than 2000 shopping centers being planned or under construction in the United States range from the modest neighborhood variety to enormous regional units. Detroit's Northland (photo) serves 550,000 people, and the even larger Cross County Center (Cover) at Yonkers, NY, serves 1½-million people.

The spectacular success of shopping centers has led to keen competition among them. Because this rivalry will increase as more and more centers spring up, managements will seek every possible means to build trade.

Lighting—a powerful modern tool for luring suburbanites to shopping centers—plays an important role both day and night.

During the day, for instance, new sign techniques permit positive identification even when the sun shines directly on the sign. And the correct window and interior lighting successfully overcome reflections that occur in glassed areas. Thus interior displays project their selling messages to shoppers on the sidewalk.

At night, lighting focuses attention on stores and displays. In addition, it

TOOL FOR LURING CUSTOMERS TO SHOPPING CENTERS—SERVES AS A POWERFUL ATTRACTION DEVICE AS WELL AS A MEANS OF ILLUMINATION.

Lighting for Today's Modern Shopping Centers

By C. M. CUTLER and R. T. DORSEY

contributes interesting and dramatic decorative effects. Lighting even helps to make an evening trip to the shopping center an exciting adventure for the entire family.

How do we go about designing the exterior lighting for a shopping center? Fundamentally, lighting must be designed in terms of the over-all merchandising plan and architectural design of the center's interior and exterior.

After considering these factors, we concentrate on the two exterior lighting categories: lighting for attraction and lighting for safety and convenience.

For Attraction . . .

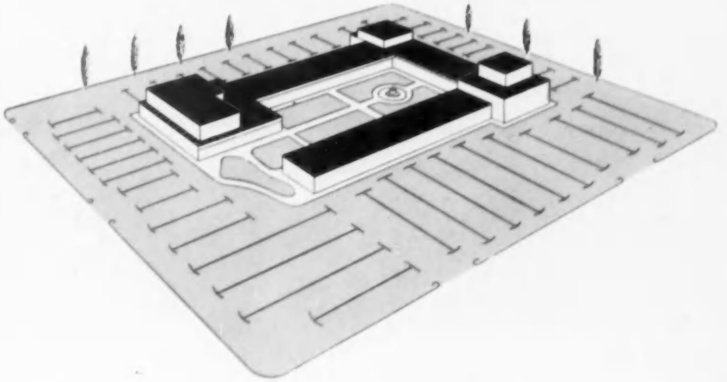
To be identified from a considerable distance, the shopping center must command the motorist's attention long before he reaches it. Moreover, attraction keeps the center prominent in the minds of surrounding residents. This can be done by mounting attraction devices atop floodlighting poles (photo, top left) or tall structures that form a part of the shopping center itself.

A large sign near the road, readily legible from the maximum viewing distance, serves as another attraction device. Slimline lamps are widely used to illuminate these signs. Recently, this service has included flashing of rapid-start lamps. In this type of circuit, heater windings in the ballast keep cathodes at the proper temperature. So far, results indicate that under ideal operating conditions more than a year of service can be anticipated. This technique also offers the opportunity for dramatic color changes.

Another recent development for large signs is the use of relatively high candlepower sources such as the 25-watt 60-

TEXT CONTINUED ON PAGE 12

HOW WOULD YOU LIGHT UP THIS SHOPPING CENTER?



To see how we did it, turn the page . . .

Planned Lighting

For

ATTRACTION

And

ATTRACTIVENESS

INCREASED COMPETITION and more shopping nights are responsible for improved landscape lighting that is designed to please the eye and to make shopping a pleasure.

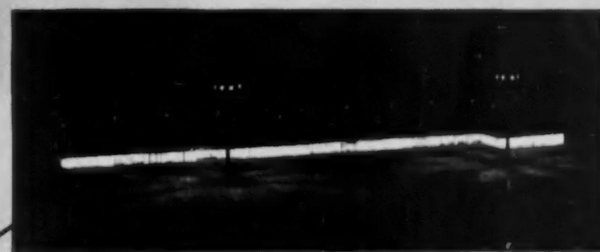
DECORATIVE ELEMENT—stylized totem pole uses reflector flood or spot lamps aimed at colorful surfaces and designs.

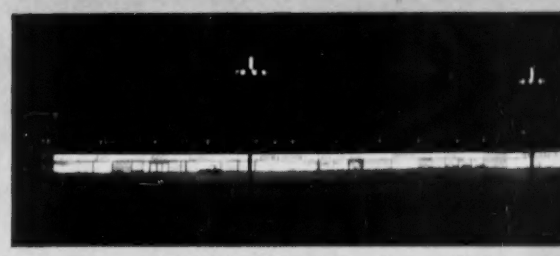
STORE DIRECTORY takes on a somewhat unusual form when it utilizes standard high-production enclosed plastics signs in varying designs.

LEGIBILITY of five-foot-high sign letters gives motorists enough time to slow down in fast-moving traffic.

LUMINOUS SIGNS lighted by slimline lamps compel attention, and downlights illuminate plants.

STREETLIGHTING TECHNIQUES (left) provide a simple lighting system, minimizing shadows. But many poles produce a cluttered effect and detract from show windows and signs. However, floodlighting (below) on 100-foot poles—above the line of sight—400 feet apart results in a much cleaner appearance.





ATTENTION VALUE is substantially improved by the addition of a continuous luminous band above the show windows of the shopping center.

MOUNTED IN A NUMBER OF WAYS, luminous plastics signs identify individual stores grouped under protective canopy. Fluorescent lamps, satisfactorily operating down to zero F, provide even illumination. Various lettering styles and colors are used.

GUIDE LIGHTING—concealed fluorescent lamps light EXIT signs; IN have reflector flood or spot lamps in plant box.

WEDGE-SHAPED SIGNS mounted at right angles to the line of traffic—staggered for visibility—light up sidewalks.

FLOODLIGHTING overhead canopies accents store fronts without detracting from silhouetted signs; downlights create pleasant walkway effects.

volt or 75-watt 120-volt reflector lamps to form the letter strokes. Aimed directly at approaching traffic, these lamps are operated at rated voltage in the daytime. Their controlled beam provides enough brightness to stand out boldly even on a bright sunny day. At night or on dark cloudy days, the voltage is reduced to avoid discomfort and even disability glare and to maintain legibility. This can be done by a photoelectric controlled dimmer or relay.

With the center identified from a distance, we must next persuade approaching people to do their shopping at the center.

To accomplish this, we create a "selling front." This includes displays seen in windows and open-front store buildings and the signs and floodlighting of building surfaces. Maintaining architectural unity while providing a high degree of individuality for individual store identification presents a major problem. It has sometimes been solved by providing above the canopy a continuous luminous band (photo, center left, page 8), say, five feet high and made of diffusing plastics or glass with four continuous rows of slimline lamps inside the cavity. On this panel are attached letters of translucent material in a wide variety of colors or opaque letters of wood or metal. This way the sign design has practically no limitations, yet the continuous panel becomes an architectural element and an integral part of the entire center. Further, attraction power substantially increases because of the large area of relatively high brightness.

We have at our disposal a wide variety of equipment and techniques available for floodlighting building surfaces (photo). The new high-output rapid-start fluorescent lamps with their high light output per foot find wide application here because they maintain their light output at low temperatures better than other common fluorescent sources. Mounted in enclosed equipment with controlling reflectors, they can be installed on top of the canopy to light the upper part of the building for silhouette letter effects; a similar element could be attached to the top of the parapet for downward lighting effects—the continuous strip becoming an architectural feature. Enclosed floodlights or reflector lamps could also be used.

Fundamentally, a shopping center is a long, low structure. We therefore pay particular attention to creating large areas of vertical surfaces to add mass, dignity, and attraction power. They can be either floodlighted or lighted from within.

The sum of all the lighting features mentioned adds up to attractiveness, measured by its power to increase sales volume. The visual sense must be captured and lighting does this. Besides using interesting materials in the structure and creating harmonious architectural composition and a pleasing pattern of brightness, we take additional steps to charm the shoppers—landscaping, landscape lighting (photo, lower, page 8) and purely decorative elements. Thoughtfully lighted sculpture, fountains, and murals add to an atmosphere of gaiety and excitement.

Still another phase of attraction power lies in influencing the traffic flow pattern for an even distribution of potential customers to each store—a design objective fundamental in the layout of the center. But much can be done by creating a pattern of brightness that will influence people to go in the desired directions.

. . . and Safety and Convenience

Motorists in today's high-speed traffic depend primarily on signs to identify a center at a sufficient distance to slow down. Upon arrival, specific entrance lighting enables them to turn in quickly and surely. Increased levels of illumination and low markers mounted next to the driveway accomplish this.

Lighted direction markers readily identify the desired route to a parking place. And a signal system to indicate empty parking spaces would expedite one of the problems. For example, a pneumatic switch could be used to change a signal at the head of each parking place from green to red when a car pulls in. Or lighted markers could identify rows and sections of the parking lot to facilitate finding one's car upon returning from the center.

During busy, crowded hours, the trip from the car to the stores may be long and discouraging; and with ice on the pavement, it may even be hazardous. Protection against damage suits demands more than ordinary care. Lighting is a vital necessity in this respect. In some centers, walkways separate pedestrian and automotive traffic. Simple lighting techniques applied here improve safety and give the customer a sense of well-being.

Large regional centers with 100 or more stores require directories to guide customers on their shopping tour. One technique uses enclosed plastics signs so combined as to express the individual signature of each store, while becoming a luminous decorative element.

The Parking Lot

Enhancing the usefulness of parking areas involves certain fundamental lighting objectives . . .

• Uniform levels of illumination: One footcandle on both horizontal and vertical surfaces is considered the minimum level of illumination, with the trend today toward five.

SPECIAL EVENTS call for special effects. Providing outlets for lighting decorations that lend a holiday spirit saves time and money.

• Reduction of shadows: Lighting at every point in the lot from more than one source reduces shadows.

• Minimum glare: Minimum candlepower at typical viewing angles minimizes glare.

• Minimum distraction from signs and show windows: Partly a matter of minimizing glare, this also involves mounting equipment high enough to be well out of the customer's line of sight.

• Good appearance of individual units: Much effort is directed to this objective, for manufacturers place more and more emphasis on appearance and style.

• Pleasing over-all effect: Minimizing the number of poles contributes to a cleaner, less cluttered appearance.

The light source itself affects the appearance of the color of automobiles and building materials, people's complexions and clothing, and foliage. You are well-acquainted with the color effects of incandescent light and generally find them acceptable. The color effects of fluorescent lighting, though somewhat less familiar, are usually accepted for this application. Standard cool white lamps widely used for fluorescent streetlighting are suitable because they produce a pleasant, slightly cool atmosphere and give excellent appearance to foliage. For a warmer effect, warm white is used.

Today, interest in using mercury lamps for parking lots is growing. Although unflattering to the human complexion and to certain colors, straight mercury light creates a distinctive effect if surrounding areas are lighted by other sources. But by general consensus, the distorted color effects tend to outweigh this advantage. And with the increasing rivalry among centers, a substantial competitive advantage is gained by using filament or fluorescent lamps for their better color rendition.

On the other hand, most mercury lamps for this kind of lighting come in color-improved versions. The red component is increased by coating the bulb with a phosphor that converts some of the invisible ultraviolet energy into visible red light. Thus red objects appear red rather than black. Though the color effects are better than with straight mercury, they are not as good as those of incandescent, or filament, sources.

The effective light source of color-improved mercury lamps is much larger than for regular mercury or incandescent lamps. Thus utilization is not usually as good, and more glare results for the same level of illumination.

Parking lots are also illuminated by mounting high-wattage floodlights on 80- to 100-foot poles, a technique having several advantages. . .

• It affords a high mounting for attraction devices that can be seen for great distances around the center.

• The floodlights are far above the level of the stores so that they do not detract from the selling front.

• The height of the poles creates a dramatic effect.

• Because the poles can be spaced about 400 feet apart, fewer are required than for streetlighting.

• Less cable trenching is required than for streetlighting because of fewer locations. High voltage carried to a transformer at the base of the pole minimizes copper size.

Lighting units mounted close to the ground—along walkways between rows of cars—offer future possibilities for lighting parking lots. With the right distribution, they could serve the double purpose of walkway and parking-lot lighting. One unit for every other car would minimize shadows. The low mounting requires careful shielding and special attention to control the light. This method creates a novel effect and lends itself to the integration of walkway, parking-lot, and landscape lighting. But such a system might cost more than others, and special provision must be made for pilferage.

Lighting's Many Attributes

Good lighting design helps to identify the center at close range and from a distance. It simplifies parking and provides safe circulation for pedestrians in the parking area. It serves to direct traffic flow and guide customers to specific areas. It beautifies walkways and malls, landscaping, and recreational areas, attracting crowds and lending distinction to the entire center. Floodlighting buildings contributes to over-all attractiveness, in addition to identification and advertising features. Lighting is also an effective means of getting attention for special occasions such as the Christmas season (photo).

Thus lighting has many attributes. The shopping center management, the individual retailer, and the customer realize its tangible benefits. And with the race for the consumers' dollars growing more heated, you can expect lighting to make an even greater contribution toward increasing the attractiveness and attraction power of shopping centers. Ω

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Recipient of the Charles A. Coffin Award for achievement at Chicago's Century of Progress Exhibit, Mr. Cutler—nationally recognized lighting authority—came with GE in 1929. He now has the over-all direction of general lighting, Application Engineering, Large Lamp Dept., Nela Park. Mr. Dorsey, also in Application Engineering, Large Lamp Dept., heads the Lighting-for-Selling group. Joining GE in 1940, he was with the U.S. Navy Bureau of Ordnance from 1941 until 1945 when he returned to the Company.

Electronic

LARGE-SCALE DIGITAL COMPUTERS, such as the IBM 650, are being manufactured on production lines by the hundreds and find use in scientific and engineering computation, as well as financial, statistical, operations research, and similar data-processing activities.

COMPUTERS (close-up of the 650) aid Mr. Maginniss, who is in charge of the group responsible for new methods and techniques in the solution of engineering problems. With General Electric for 15 years, he is Manager, Special Engineering Investigations, Analytical Engineering Section, Apparatus Sales Division, Schenectady.

Although the potentialities of computers were recognized early in the 19th century, large-scale digital computers are a recent development. Ten years ago, computers as you know them today were not in existence. Now such devices are no longer just experimental models. Hundreds of computers are being manufactured on production lines and find use in scientific and engineering computation, as well as financial, statistical, operations research, and similar data-processing activities.

Development and Growth

As a result of this new tool's unprecedented growth, many thoughtful people make seemingly fantastic claims for the computer's effect on our economy—in fact, on our whole civilization. Some foresee a second industrial revolution and look with concern on its social effects. Others point out the striking engineering and scientific advances made possible only by performing in minutes or hours lengthy calculations that would be utterly unjustified economically by old-fashioned pencil-and-paper methods.

An article titled "H-Bomb: Its Story" in the *Christian Science Monitor*, July 22, 1954, quotes from Dr. Norris Bradbury's testimony at the security hearing of Dr. J. Robert Oppenheimer. Speaking of a brilliant discovery made by Dr. Teller, which virtually assured that a thermonuclear bomb could be built, he said:

"Had this idea occurred in 1945, 1946, 1947, or 1948, or almost anytime before it did occur, we would not have known how to use it in an effective military fashion. . . . We would not have been able to make the relevant calculations for mechanical reasons. . . .

"One of the stumbling blocks in [those] years was the absence of computing machinery, the so-called electronic brains of sufficient capacity and magnitude to handle the type of computations which were involved. . . . No calculating machines existed that would permit some of the particular problems to be explored."

Furthermore, the computers are much less likely to make errors than humans. A modern machine that carries out 2000

c Computers—Engineering Timesavers

By F. J. MAGINNISS

to 5000 operations per second needs to operate without errors for only one-half hour to equal the output of a human being computing 8 hours a day, 5 days a week for 8 years—and all this without his making a single slip.

Training of Personnel

But machines alone are not enough. Finding qualified personnel to program, operate, and maintain them poses an immediate problem. Universities, computer manufacturers, and users of the equipment are setting up training courses to fill this growing need. The General Electric Company has established such a course to train engineers and engineering assistants. This course is given not only to those directly concerned with the computer's operation but also to engineers who are interested in learning how these machines can be made useful to them. The response has been enthusiastic, and probably the major benefit has been the recognition by engineers that many of their day-by-day problems can be solved by computers.

A design engineer will discover many tedious, repetitive calculations that for machine computation need to be programmed only once. The application engineer will think of a system problem that could easily be investigated by automatic computing methods. "Automatic-digital computer" becomes more than a name to the engineer after he tries his hand at programming one of his own problems or sees the computer run through a job he has previously done the hard way.

One of GE's analytical components has been using digital computers for nine years, and during this time the computers have helped in more than 200 different projects within the component.

Mathematics of Engineering

Before turning to specific engineering problems, let's answer these questions: What kind of a tool is the digital computer? is it like an engineering assistant with a desk calculator? how does it differ from a thinking human being?

Let's suppose that you are leaving a room. You see a sign by the light switch reading, "Please turn lights off when you leave the room." Probably you will follow instructions unless others using the lights are left behind. Not so with the electronic "brain." If ordered to turn off the lights, it would turn off the lights. Computers can't use judgment unless it's programmed into them.

But now suppose the lights are not on in the first place. You read the sign subconsciously, realize that it doesn't apply to you, and go on about your business hardly giving the lights a thought. But the poor computer probably stands there and beats its brains out trying to figure out how to turn off a light that is already off. To have the computer do what you think you are asking it to do, be sure you have figured out all the angles.

When an engineering assistant solves a set of simultaneous linear equations, she consults her fund of stored knowledge and follows a learned routine. The computer can't do as well, unless furnished with a similar fund of stored knowledge. It can only add, subtract, multiply, divide, compare, and perform other simple operations.

To be as proficient as the engineering assistant, the computer must be educated. In this process the assistant tabulates all her steps and stores them symbolically on punched cards or their equivalent—magnetic drum, tape, or some other storage medium that the computer can recognize. This recording of the assistant's knowledge in a form transferable to the computer constitutes a subroutine that is filed for future use. Later, when similar equations must be solved, this subroutine placed in the main routine supplies the computer with all the necessary background information, enabling the computer to do as well as the engineering assistant—only faster.

Thus with a new computer you must first build up a library of useful subroutines. You'll want to be able to command the machine to invert a matrix, to extract the roots of a polynominal, to fit data to a curve, and to perform other functions. You must not only give the machine a set of rules for keeping track of the decimal point at all times but also set up a routine to make the computer check itself for errors—one that cannot always be programmed into an engineering assistant.

Engineering Problems: Design . . .

Engineering problems cannot be completely categorized. But let's divide them into broad areas to illustrate the variety of problems met in a typical engineering organization. By discussing problems in each area, you'll see how digital computation speeds up problem solution.

A design engineer has two functions. One is creative: the decision to use new materials, methods, and processes to produce a better product that can benefit both user and manufacturer. In performing this function, the design engineer does the most good for his customer, employer, and himself. His satisfaction comes from the knowledge that he is making an original contribution.

Although noncreative, his other function has importance, too: calculating maximum flux and current densities in the equipment; choosing proper wire size and number of turns, keeping within current density limits; determining hot-spot temperatures, stresses, losses, efficiencies, torques, forces, voltage gradients, plus a multitude of other variable quantities that affect the performance of the equipment being designed. Mainly routine, these calculations require very little brain power. If the equipment does not meet its specification, something must be varied and the calculation repeated. But the decision of what to change and how much is usually fairly routine. And here the automatic digital computer enters the picture.

A routine design calculation characteristically includes the engineer's use of curves. When checking out a design by hand, he spends much time looking up information from charts that have evolved over the years or that are graphical solutions. For the computer to carry out these calculations, a means for looking up data from curves must be built into its memory. If these curves are solutions of equations, there is no problem; the machine just substitutes the proper value of the variable into the equation. If they are empirical data, some curve-fitting technique must be

HUMAN BEING would have to compute 8 hours a day 5 days a week for 8 years without error to equal half-hour output of modern computer such as the IBM 702 or 704, which carries out 2000 to 5000 operations per second, also operating without error.

used. An equation is evolved to represent the given curve within the required limits of accuracy and the coefficients of the equation stored in the computer's memory.

Field . . .

When confronted with a field problem, you look for quantities not localized in space. For example, you might want to find the temperature of the water in a lake. Certainly, no one number can be given as the temperature of the whole lake. Near the surface where the sun hits the water, it will be warm; near the bottom, it will be cooler. The shaded surface will be cooler than that in the sun. If a small stream flows into the lake, its temperature will influence the lake temperature where it enters. And so this is a field phenomenon. You have to determine the fluid temperature throughout the lake—a temperature field. Thus your problem can be solved only if a numerical value can be put on the temperature at every point in the field.

Similar problems may include velocity fields—determining the gas velocity at every point in a jet stream; electric or magnetic fields—determining the electric intensity or the magnetic flux density in portions of electric machinery; and pressure fields—evaluating the maximum pressure loading in the journal bearing of a large rotating machine.

The answers to all these field problems are evaluated at every location in a given space. Practically, only a finite number of locations are considered. In the lake-temperature example, for instance, let's simplify the problem by using the temperature on the surface of the water. Next, lay down a checkerboard array of lines on the lake's surface and determine the temperature at each of the intersections of these lines.

You see how the problem has been simplified. Instead of trying to obtain a solution at every possible point in space, you limit yourselves to, say, 100 space locations. Knowing the temperatures at two adjacent points, you can make a fairly accurate estimate of the variations between points.

In general, field problems can be translated into partial differential equations that usually must be solved by numerical means rather than analytical means. Again, the automatic digital computer enters the picture.

First, estimate the answer—such as the temperature at all the intersections of the network in our example. Then follow an iterative procedure, modifying the temperature value at each point on the basis of certain mathematical rules. When this procedure has been carried out enough times, you'll have approximately correct values for the temperature at all the points. The extent of the answer's accuracy depends largely on the number of iterations and how fine a network of points you laid down in the field. A simple field of 100 points can require tens of thousands of calculations to obtain a satisfactory solution. Think how this number would multiply if you considered 10 times as many points or the depth of the lake. Only an electronic computer could solve your problem in any reasonable length of time.

Electric Power System . . .

To solve the electric utility engineer's problems originating with electric power systems, specialized computers of the analog variety are needed. How does this type of computer differ from the digital? The digital computer does arithmetic just as you do using numbers. Only the number of digits carried limits the precision of the results obtained from a digital machine. Some digital-computer routines have been set up to use as many as 20 significant digits in every operation, although as a rule only 6 or 8 are used.

The analog computer requires an actual measurement of some physical variable to solve the problem. The a-c network analyzer is an analog computer made up of models of the various components of an electric power system—generators, transformers, transmission lines, and others. These are interconnected, forming a miniature of an actual power system; and the quantities of interest such as voltages, currents, and power flow are measured by reading meters connected into the system. You can read a meter with precision only to three or four significant digits.

One important power system problem—load-flow study—recurs continually. Predictions are made as to where new power system customers will be located, how much their power requirements will be, and how much load growth will occur among the present customers. Then the utility engineer must determine how his company can best supply this load. This involves many questions:

What new equipment will be needed? where should new transmission lines be located? will it be desirable to interconnect with a neighboring utility company? will the power system be able to ride out the sudden shock of a lightning stroke? where and how much reserve generating capacity is required so that an unexpected outage of a generator will not affect service continuity? The a-c network analyzer is frequently used to obtain some of these answers.

Some power system engineers have looked into the possibility of using digital computers in this type of load-flow calculation. But practical applications have been slow. Few electric utilities have the large-storage-capacity high-speed digital machines necessary for this kind of work. Being a physical model, the a-c network analyzer adjusts itself naturally to carry the right amount of current in every circuit, keeping the system in equilibrium. With a digital computer, however, a vast number of equilibrium conditions must be established mathematically. To compete with the network analyzer, the digital computer must be tremendously fast. The size and intricacy of the modern power system would require a powerful digital machine.

Studies indicate that a digital-computer method could be feasible for the load-flow work in the smaller systems—those containing no more than 24 lines. The results show that the digital computer could compete with the network analyzer, economically and timewise.

Another power system problem concerns its operation following a disturbance, say a lightning stroke. The system may lose synchronism and be put out of service temporarily. To prevent such occurrences, many power companies make studies on the a-c network analyzer to see whether two or more parts of the system might swing apart during disturbances. In the past, tedious hand calculations were alternated with network-analyzer measurements in such a problem. To speed up these studies, GE added to its analyzer a special analog device—the swing curve calculator.

. . . and Trajectory

Not all engineering jobs handled by computers directly benefit industry. The military instigates many of a classified nature. However, those in the field of missile trajectory have received wide publicity. There are two types of missiles: those in free flight after leaving a gun; and those guided by a control system to travel a prescribed course.

From your physics courses, you'll remember that an ideal missile traveling in a vacuum follows a parabolic trajectory. If you know only its initial velocity and angle with respect to the horizontal, you can immediately determine the highest point of its flight, its range, and the time it will take to reach the target. But in real life, you do not have ideal conditions. Thus it becomes imperative to use computing equipment. Differential equations that can be solved step by step along the path of the trajectory describe the motions of such projectiles. Actual conditions prevailing at each instant of flight are factored in.

The tremendous speed of some of the modern computers often enables the computed trajectory of the missile to be traversed much faster than the actual one. Many early computers manufactured were used to prepare firing tables.

That some missiles contain a built-in or an external control system to keep them on course presents only a minor complication. Depending on the complexity of the control system, more or less terms are added to the equation that expresses the equilibrium of forces acting on the missile—only a question of degree, not kind.

The methods used for determining the paths of shells and other massive missiles were applied also to electrons, the smallest missiles. Other problems studied are the paths of electrons in vacuum tubes subjected to various kinds of electric forces and the paths of the electrons projected down the picture tube of your TV set—putting an image on the screen.

Economic Studies

Without digital computers, many economic problems probably would not be carried out. In the face of rising prices, electricity has remained an inexpensive servant. For utility engineers continually seek ways to keep the cost of electricity low by improving the efficiency of their operations. They make sure that electricity is always generated where generating and delivery costs are low. Many factors enter into an economic engineering analysis of this kind. Let's assume that a power system is in operation. An industrial customer, about to start operations for the day, will require a large amount of electric power. Which generator on the power system should pick up the load? The utility company's incremental cost of the additional load will depend on the incremental fuel cost at each of the power stations on the system. You must also consider whether a water power station or a steam station is involved. Although the fuel cost is zero in dollars for a water power station, the water used up may not again be available.

The loss incurred in getting the power from the generating station to the customer also affects the economic delivery of power. Electric current, like water, follows the path of least resistance. Forcing current to travel a high-resistance path appreciably raises the cost.

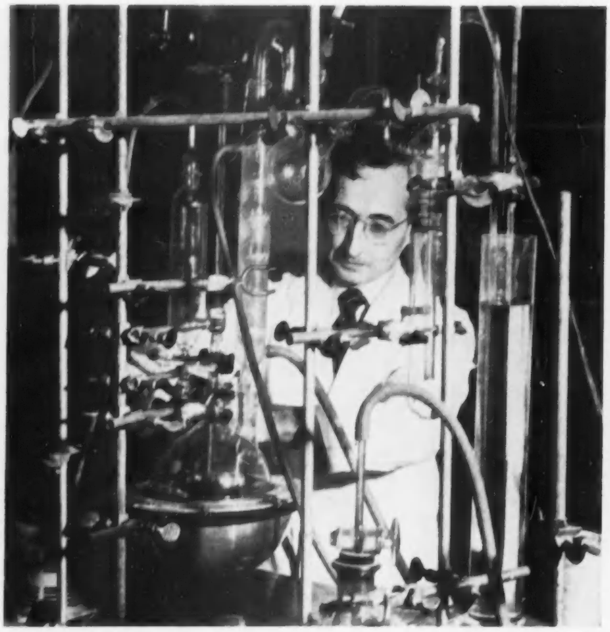
A similar economic problem arises when one utility sells power to another and for geographical reasons delivers it across the transmission facilities of a third interconnected system. How much should this innocent bystander charge for the additional system losses incurred as an intermediary?

These economic problems usually involve lengthy matrix manipulations. Without a high-speed computer, calculations would require so much time that the results would be worthless. The load dispatcher on a power system wants up-to-the-minute information at all times to aid in making the best possible distribution of his product—electric power.

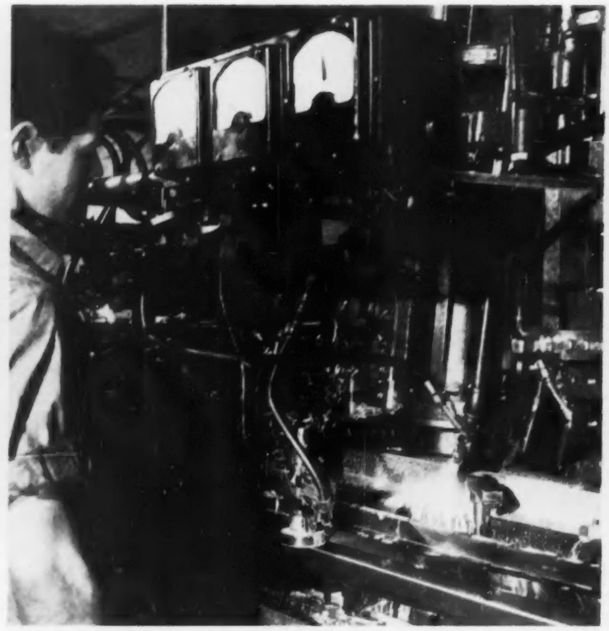
A slightly different problem confronts an electric utility company in maintaining reserve generating capacity to meet power demands. The electric power business differs from the usual run of business because its product cannot be warehoused. Generation, transmission, and distribution are instantaneous and "on demand." The electricity that lights your lamps is manufactured with the turn of the lamp switch; production ceases when the switch is turned off.

Naturally, some so-called spinning reserve must be available to supply unexpected, or peak, loads. The number of generators, boilers, and other central-station equipment will depend on many factors, including the forced outage rate for the equipment. If reasonable assumptions about these rates can be made, probability methods will determine how many hours or days per year the station will be unable to meet the peak-load demands.

Other areas of engineering problems where automatic digital computation have proved of value include circuits, stress and vibration, electric machinery, statistics, and operations research. The universal engineering applicability of these electronic computers constitutes a potent factor in our nation's constantly rising standard of living. Ω



ANALYTICAL The answer to *what* and *how much* is often the key to solving some vital problems.



INORGANIC Phenomenon involved when a tool tip shears through a metal is still being investigated.

Chemistry in the Electrical Industry

By DR. R. M. BRISSEY

Undeniably, a major factor in the progress of American industry is our activity and knowledge in the basic sciences. Discoveries resulting from such work improve old products and create new ones.

How effectively new materials and processes reflect these scientific advances determines the expansion rate of our industrial output—and the rapid rise of our standard of living. An example of expansion and growth, based in large part on scientific achievement, is the electrical industry.

Seldom perhaps is the chemist associated intimately with the electrical industry. Yet he is there. New materials and processes, so basic to progress, are his handiwork. In this era where advanced engineering concepts bid fair to outstrip the capabilities of materials, the chemist plays an increasingly important role.

Within the amalgamation of science and technology called industry are four branches of chemistry: analytical, inorganic, organic, and physical. Chemists in each area work within fairly definite limits, though sometimes their work overlaps. This is particularly true of the physical chemists.

But let's consider separately and in sequence some of the contributions and challenges in each branch.

Analytical Chemistry: Two Questions

The analytical chemist's primary job is answering two important questions: What is it? how much? Frequently it's difficult to get answers to these questions, simple as they may seem. Often they are the key to solving some vital problem.

In the electrical industry, analytical chemists continually supply data essential to research in chemistry and metallurgy. Some seek an elusive chemical factor responsible for production difficulties or product failures. Others concentrate on improving analytical methods to assure that materials will meet specific requirements.

In his quest for answers, the analytical chemist increases his use of instruments.

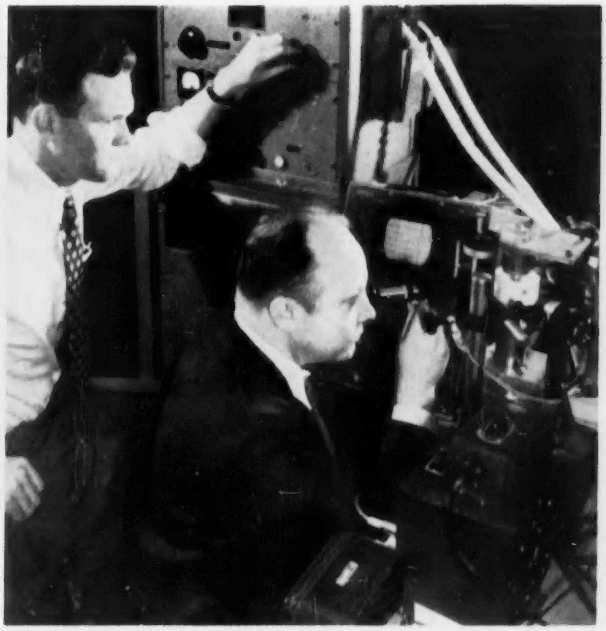
To identify components, he uses the spectrograph, which records the intensity of radiation emitted by samples subjected to an electric arc, or spark. From information thus obtained, the chemist rapidly gets quantitative results that answer the question: How much?

With an x-ray spectrograph he can accomplish the same result. Here the sample is subjected to intense x rays. Characteristic x rays in turn emitted by the sample are a measure of the elements present. Relatively simple, x-ray spectra are easier to standardize than the spectra from a regular spectrograph.

Another method the analytical chemist employs is x-ray diffraction for identifying materials by establishing their atomic arrangement and spacing. Vacuum-fusion analysis furnishes him with data on the oxygen, nitrogen, and hydrogen content of metals. Infrared and mass spectroscopy assist him in establishing the composition of complex nonmetallic materials that for all practical purposes cannot be chemically separated.

Results obtained by the analytical chemist contribute to successful research, development, and production—sometimes opening new fields of knowl-

ORGANIC Creation and application of new materials, such as silicone rubber, substantially reflect chemists' skill.



PHYSICAL In an effort to analyze chemical phenomena, physical chemists apply physical laws to chemistry.

edge. An analysis of black film on the commutator of a motor, for example, was an entering wedge in an electrical problem that baffled engineers. Meticulously performed and wisely interpreted, this analysis led to important new knowledge concerning the effect of chemical films, moisture, and environment on sliding electric contacts.

Emphasis today is on materials—understanding their behavior and improving their performance. Add to this their increasing complexity—for example, in high-temperature metallurgy—and you see how important are the two questions an analytical chemist must answer.

Inorganic: Everything But Carbon

The inorganic chemist deals with the behavior of compounds based on all the elements except carbon.

What are his contributions? Let's first examine corrosion because of its importance to many industries, particularly the electrical industry.

Much of the chemistry involved in corrosion and its prevention is mainly inorganic. Chemical processes commonly used to obtain protective films, such as oxide coatings, involve inorganic reactions. (Nature's own oxide film, a millionth of an inch thick, prevents aluminum corrosion.) Also inorganic in nature is the chemical operation of plating, used to decorate and protect objects and to prevent wear.

As machines operate at higher and higher temperatures—as they will with progress—the natural oxidation of their metals and its prevention become important problems. This, too, is part of the inorganic chemist's domain.

Materials of inorganic compounds insulate rotating electric machinery that operate at extremely high temperatures. Two widely used materials are glass and mica, with ceramics becoming increasingly important. Silicone insulating materials, outstanding for their temperature stability, have a close kinship with an inorganic material—ordinary sand, the kind that you see on the beaches or used for making concrete. (Chemically speaking, silicon linked with oxygen takes the place of carbon in the molecular structure of silicones.)

Consider for a moment the commonplace but essential operation of cutting and grinding metals. Liquids are flowed over the cutting-tool's tip, cooling and lubricating as the tip shears through metal. Chemists have found that reactive elements in a cutting liquid strikingly affect a tool's life and the quality of the metal surface as well.

The phenomenon involved when a tool tip shears through a metal is still far from being thoroughly understood. Yet the chemist believes that with many metals active chlorine or sulfur in the metalworking fluid influences the cutting operation.

For an extremely simple concept of this phenomenon, visualize a chemical reaction between the metal being cut and the active chlorine or sulfur in the working fluid. Remember that this reaction takes place under the influence of extreme heat and pressure at the tool tip. The products of this reaction rather than the metal itself are sheared by mechanical forces on the cutting tool.

Chemical reactions of this sort can be extremely significant in a machining operation. Realizing the importance of metalworking to the electrical industry, you can only conclude that this field needs the talents of the inorganic chemist.

Organic: Carbon Is the Keystone

Of all the nonmetallic materials used in the electrical industry, by far the greatest number are organic materials.

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Dr. Brissey began his association with General Electric in 1950 at the Thomson Laboratory, Lynn, Mass., where he later became Manager of the Chemistry and Insulation Department. Presently, he is Manager, Engineering Laboratory, Medium Induction Motor Department, Schenectady.

ORGANIC POLYESTER RESIN IS USED IN A SHIELD THAT MINIMIZES VIBRATION PROBLEMS.

Generally speaking, organic materials have structures based on the element carbon. Other elements present may be hydrogen, oxygen, nitrogen, and occasionally metallic elements. Paradoxically, silicones are also considered organic products, though the oxygen-silicon linkage that forms their backbone is inorganic in character.

In recent years the organic chemist has produced an abundance of new chemical materials. Properly utilizing them to improve products and simplify production requires talented and versatile organic chemists. Such chemists engage in two broad types of work: material development and application.

Material development involves chemical synthesis, or the building up, of new compounds. It can also mean modifying some existing compounds to produce a desired set of properties. Material application, on the other hand, deals with selecting and evaluating a material—or combination of materials—for use in a product or its production.

Logically, you probably think first of insulation when considering organic chemists in the electrical industry. Rightly so. This is a major area of interest.

Many synthetic materials of recent origin are appearing in today's electric equipment. They permit higher operating temperatures, decrease the volume of insulation needed in electric equipment, and may also simplify manufacturing processes. Examples of such insulating materials include polyesters, epoxides, silicones, and polyurethanes—all falling under the general heading of organic polymers.

Polymers are materials made up of giant molecules formed by a considerable number of simple molecules in combination. Numerous chemical variations occur within each polymer family, depending on the exact nature of the simple molecules and the conditions they react under, which influence physical and electrical properties obtained.

The variety of organic polymers demands the talents of chemists who understand this expanding field. They must astutely evaluate and select materials that will contribute most to progress. Wire enamels, film insulation, and electric insulating varnishes are examples of such materials. Thanks to these developments, the design engineer could get more power from electric motors.

Recently from the laboratory emerged a new wire enamel having much better temperature stability than its predecessors. A product of organic chemistry, it will have far-reaching effects in the electrical world.

Interest in polymers is increasing in another area: structural plastics. Glass in the form of fibers, cloth, or other reinforcements is treated with resin and then shaped and cured to get structures low in weight but high in strength.

Structures of reinforced plastics are well suited to electric equipment requiring nonconducting or nonmagnetic properties plus strength. Noncorrodible, they can be designed to give unusual strength in specific directions. Frequently, you can form them into unusual shapes more readily then metals. Structural plastics can serve as shields or housings where vibration is a problem because the structure can rapidly absorb the energy causing vibration.

The resins produced by the organic chemist are used more and more to encapsulate electric equipment. Usually, encapsulation involves pouring a liquid resin into a mold surrounding an electric component to insulate, support, and protect it. Then the resin is cured to a solid state by either heating it or adding another reactive chemical.

In this manner, too, portions of electronic circuits are encased. Small rectifiers, instrument transformers, and motor windings receive similar treatment. Special properties—such as flexibility, matched expansion coefficients, and thermal conductivity—are sometimes needed to meet required operation. Naturally, these properties demand that organic chemists synthesize resins and establish suitable operations for production.

Lubricants—another area for the organic chemist—will grow in importance as technology moves to higher temperatures.

For the most part, oils and greases used in machinery operating at high temperatures are based on synthetic compounds. Their performance has been improved from time to time by adding organic materials that act as stabilizers to inhibit, or restrain, oxidation.

Organic chemists continually strive to impart the elusive property of better lubricity to oils and greases that are stable at high temperatures. Lubricity is the ability of thin films of a substance—oil, for instance—to reduce friction between materials. The chemist's goal: lower friction at higher pressures so that more combinations of materials will operate at higher speeds and temperatures.

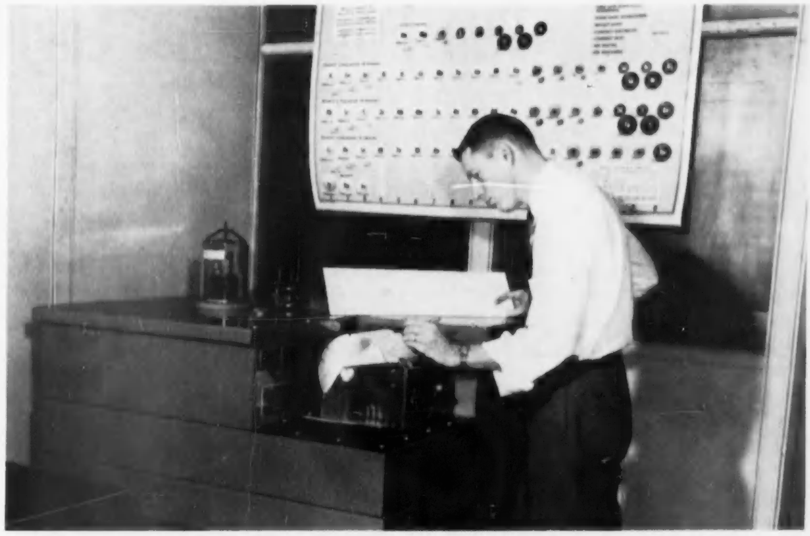
The use of adhesives in the electrical industry is stimulated by the properties that the organic chemist is obtaining with some of the newer resins. Properly applied, synthetic adhesives greatly simplify manufacturing. But as good as today's adhesives are, chemical developments aimed at still better ones are under way.

Some of the resins the organic chemist uses in adhesives are also important in paints that protect and decorate. In this field of protective coatings, unusual environmental conditions confront the chemist at times. Solving such problems means selecting a protective finish, then testing it either in the laboratory or under actual conditions, and finally making recommendations for its use.

Many nonmetallic materials are required in the electrical industry, presenting a tremendous challenge to organic chemists. For example, product engineers frequently wish for some new material with such unique properties that, if available, it would revolutionize their product. Organic chemists do meet some of these demands. Among the new materials they've created, many promise to fill the demands of other unusual engineering applications.

But success in one application creates demands for materials in other new applications. As a result, materials with properties scarcely dreamed possible a few years ago are now commonly used. For instance, silicones are noted for their stability under temperature extremes. Also, the epoxide resins shrink very little when cured—a highly important property in any molding operation. Additionally, their moisture resistance is excellent and their adhesive properties outstanding. Another example, synthetic polyurethane rubber, shows unusually good wear resistance.

The engineer in the electrical industry fully recognizes the importance of new materials development. The organic chemists in both the electrical and chemical industries are making great contributions in the continuance of these developments. The degree to which new materials are created and applied substantially reflects their knowledge and skill.



INFRARED SPECTROPHOTOMETER HELPS ESTABLISH COMPOSITION OF NONMETALLIC MATERIALS.

Physical: No Bounds

The physical chemist works in a field of obscure boundaries. His work overlaps physics on the one side and all branches of chemistry on the other. In an effort to analyze chemical phenomena, he applies the laws of physics to chemistry. Every day these physical-chemical concepts help in making industry's products.

To understand, say, semiconductors, the physical chemist studies atomic structure and energy levels within materials. He may study the mechanism or rate of chemical reactions with different objectives in mind: to prepare a new compound or to establish a satisfactory procedure for curing varnish in an electric motor. Studies of how insulating materials behave under extremes of temperature also call for physical-chemical laws.

As part of his job, the physical chemist sometimes predicts the performance and character of materials useful to the electrical industry. Take greases, oils, and fuels, for example. He may measure their vapor pressure and relate it to evaporation, deriving some mathematical relationship between the two.

Phenomena at a material's surface include factors important to untold numbers of operations. And these, too, are subject to the physical chemist's attention. The absorption or diffusion of water, for instance, can affect performance of an insulating material. It can change the strength of structural plastics. Or it may influence the behavior of photoelectric devices.

Sliding electric contacts, of great importance to industry, involve the application of physics and chemistry in the study of their performance.

On a motor's commutator, thin films—so thin that they must be viewed under a microscope—offer varying resistance to the passage of current. Relating this resistance to the film's thickness is only one aspect of the physical chemist's investigation of this problem. Liquid dielectrics—insulating fluids vital to electric power transmission and distribution—are also in his field. The physical chemist strives to correlate dielectric strength to molecular properties and to analyze what happens when a liquid is stressed by voltage, a phenomenon not yet fully understood.

Another facet of surface chemistry is that of fillers—the bulky substances used in formulating such materials as plastics and rubber. Through research on fillers, the physical properties of many materials are improved. The improved mechanical strength of silicone rubber over the past three or four years attests to the importance of the physical chemist in this work.

His approach is also important to the understanding and control of corrosion—another familiar surface phenomenon. The same could be said of friction, wear, and lubrication.

Overlapping Interests

You probably noted the overlapping of the chemists' contributions to the electrical industry.

Only a unique undertaking is restricted to a single branch of science or engineering—a tenet applying equally to chemistry. The analytical chemist uses inorganic and organic chemistry plus the laws of physical chemistry. The organic chemist uses analytical and physical chemistry. And a similar interplay is involved in the other branches.

Though the chemist possesses great skill and knowledge, final utilization of chemical materials or principles rests with the engineer. Manufacturing, too, plays its role before distribution of the material—either as part or all of a finished product—to its ultimate user.

In effect, then, the chemist belongs to a significant technological team. His contribution is basic, for it deals with the science of materials and their behavior—two factors vitally important to the electrical industry. Ω

Integrating Two Professions: Engineering and Sales

By W. V. O'BRIEN

So often the only successful route to business or professional success seems to lie in the complete specialization of studies. But one of the more encouraging signs in a few colleges and universities is the recent trend away from this practice. Take, for instance, the field of medicine: The rebirth of pride in the almost forgotten general practitioner reveals his contributions and opportunities while taking nothing away from the specialist.

This situation parallels engineering and sales. An explanation may enlarge your understanding of three major areas within this structure: the importance of the sales function to the engineer; the close integration of engineering and sales; and some opportunities within the sales-engineering profession.

Undergirding Industrial Productivity

To the engineering profession goes the credit for the engineering and scientific advances in technology that undergird industrial productivity—the source of America's high standard of living. But the salesman, the marketing man, or the distribution man puts the engineering advances to work. Production goes to only one of two places: the consumer or inventory. Thus as we sell, so shall we live.

Not all buying decisions can be predicted on filling expressed needs; a third are either made impulsively or as optional choices. The importance of sales efforts rests not only in making good use of technological advances but also in achieving statistical goals that reflect the nation's progress.

Based on this one-third buying, forecasters could add a bold-faced footnote: "All this will happen only by an all-out sales effort; otherwise the most optimistic estimates can be meaningless." Buying the future with a bag of statistics simply cannot be done.

Nothing happens until somebody buys something. Estimates indicate that one industrial salesman keeps 31 factory workers busy.

Now, if new factory jobs are created through extra sales effort or additional sales manpower, the results take on even greater importance. According to the Economic Research Department of the U.S. Chamber of Commerce, the creation of 100 new factory jobs in a community has far-reaching effects: 296 people move into the community; 112 more households are established; 51 more children go to school; 4 more retail businesses open; 107 more passenger cars are registered; 74 additional jobs are created; personal income increases by $590,000; new bank deposits amount to $270,000; and retail sales increase by $360,000 annually. These figures re-emphasize the importance of selling as the beginning, not the end, of a dynamic process.

Need for Integration

Although the effects of such sales efforts should be noted, let's not overlook the needs. A recent long-range forecast of the nation's economy estimates that our gross national product by 1970 will be almost 50 percent higher than today's. But to reach this figure, the average annual residential use of electric power will approximately triple today's usage, reaching 7700 kw-hr.

A new industry-sponsored program, "Live Better Electrically"—believed to be the largest mass-market development program ever undertaken—shows the need for sales efforts matched to productive abilities. A major investment in men, time, and dollars by all segments of the electrical industry, it aims at selling every American on the idea of better living through electricity.

Advertising—an important segment of the selling function—has frequently been a favorite whipping boy of some professional areas such as that of medicine. But recently, the President of the American Academy of General Practice cited several pertinent contributions by pharmaceutical manufacturers for which physicians are grateful, including the financing of publications, defraying of convention costs, visual aids, and so on.

And advertising also shares in financing the sources of engineering information, including our great technical journals.

When the sales and engineering professions are largely pure, or distinct, a thorough understanding of their contributions to each other takes on a real significance. A popular misconception: sales and engineering are always distinct professions. While certainly not true in the producer-goods field, it may be in the consumer-goods field. With a completely pure separation, the narrowing of channels may hurt both professions and the individual as well.

Basically, of course, the interconnection lies with the need for each engineer and salesman to sell himself, his ideas, his plans, and his methods. This shouldn't imply any loss of dignity or any resort to the outmoded tactics of a huckster; neither should it permit the working habits of a lonely recluse who would wait to be discovered.

Areas for Sales-Engineering

General Electric marketing functions serve as an example of the much larger areas closely integrating sales and engineering (Box). The scope of these integrated functions reveals the vast opportunities that reside within the sales-engineering profession. The same close alliance of engineering and sales exists to a large degree throughout industry, including the electric utility industry.

The marriage of sales and engineering assumes particular significance in the producer-goods field. Some 23 percent of all the engineers recruited by GE find many opportunities in the Apparatus Sales Division, which has the responsibility for the sale of producer goods.

Comprising the heart of the sales-engineering team are the engineers who serve as a . . .

• Sales Engineer—the direct contact concerned with the patterns of customer satisfaction: likes and dislikes, past purchases, buying habits, and future plans. Requirements: a sound engineering background plus the perseverance of a reporter, wisdom of an elder statesman, tact of a diplomat, enthusiasm of a teen-ager, patience of a teacher, and the broad shoulders of a country doctor.

• Application Engineer—a specialist in systems and, in a sense, a con-

Mr. O'Brien is Vice President and General Manager, Apparatus Sales Division, General Electric Company, New York, NY.

sultant for the customers' engineering problems. Requirements: a detailed study of the application of electric equipment to industrial processes, knowledge of the customers' operations, and the familiarity with products necessary to solve the customers' problems.

- Product Specialist—an expert in a specific product line, who brings extensive knowledge of a particular apparatus, including design and application features, to the solution of the customers' problems.
- Service Engineer—once the equipment is sold, he assumes the responsibility for making certain that the equipment is properly installed and continues to operate efficiently while in service.

Other supporting areas of marketing contribute to sales success, both in the field and at headquarters: field service-shop operations and headquarters analytical engineering staff. The latter immeasurably helps the sales effort by aiding in long-range system studies and establishing utility company needs with the most modern timesaving equipment.

SALES-ENGINEERING INTEGRATED WITHIN MARKETING FUNCTIONS

CUSTOMER RELATIONS	To interchange information; to coordinate sales; and to create, build, and maintain good relations with potential customers as well as customers.
MARKETING RESEARCH	To study current conditions, trends, forecasts, and similar fields.
PRODUCT PLANNING	To work with product function, quality, appearance, packaging, simplifications, and pricing.
ADVERTISING AND SALES PROMOTION	To prepare publicity, space advertising, and instruction books and do copy research.
SALES	To engage in sales analysis, training, management, and planning; to formulate objectives, policies, and merchandising programs; and to recommend sales channels.
PRODUCT SERVICE	To handle product standards, plans and programs, warranties and protection plans, and service-shop operations.
MARKETING ADMINISTRATION SERVICE	To deal with sales forecasting, budgets, production scheduling, warehousing, and marketing analysis.
MARKETING PERSONNEL DEVELOPMENT	To recruit, select, train, and place personnel, as well as handle compensation.

New Fields Offer Opportunities

Even such an advanced field as nucleonics needs the sales-engineering function. A design engineering specialist at Hanford Atomic Products Operations (HAPO), Richland, Wash., recently observed: "The term 'nuclear engineer' has generally been understood to describe engineers who conduct technical development and design. In so new a field, development naturally receives the most prominent attention, and the need for this function will continue to be a major one. But the transition from the initial phase to full-fledged industry will bring into prominence additional functions."

These functions include: sales and application engineering — representing the product to the customer and matching its characteristics to the needs of the system and related equipment; installation and service engineering—putting a complex new product into service and analyzing and correcting troubles that may develop.

Two relatively new fields offer further evidence of the professional scope and importance of today's combined marketing-engineering opportunities: operations research—involving the determination and application of pretested methods of action that help management make the right decisions, not on a hunch but from systematic study and synthesis; motivation research—studying the basis of human actions and impulses, obviously important to the entire marketing area.

Integration in all these sales-engineering areas protects rather than impairs the engineering investment, enabling a company to better serve its customers. At the same time, this encourages the engineer to use his abilities over wide areas of opportunity.

After recognizing the significance of sales-engineering, engineers should look within their own company for promising opportunities in some phase of sales-engineering that would broaden their experience.

Overcoming Prejudices

The old prejudices against selling should be overcome. Despite the contributions of the sales engineer, too many people in too many places still retain the old concept of the outmoded ill-trained door-to-door salesman. Good comic-strip material, it's as outdated as a 1924 Essex.

And prejudices do exist. A recent article in an engineering publication states: "Too many engineers turned to salesmanship. The word 'professional' means something unique, something that no one else except trained men can do. It implies personal dignity and proper standards."

To label this view as a slight misconception would be more than kind. But everywhere you can see other examples of prejudice. Why, for example, do we sometimes avoid the word "salesman"? Field representatives, sales representatives, sales agents, and a dozen other words suggest a lack of confidence in the word.

Young men in schools and colleges must be advised of the opportunities in the sales-engineering profession.

Someone once said that there are three kinds of people: those who don't know what's happening; those who watch things happen; and those who make things happen. Both the engineer and the salesman belong in the third group. And integrating the sales and engineering professions reinforces the contributions of this group—the men who make things happen. Ω

TORTURE CHAMBER duplicates and accelerates severe service conditions in the laboratory. Authors Norman and Thompson observe surface sparking on molded instrument transformer.

Nontracking Insulations Spur New Designs

By R. S. NORMAN

and

J. D. THOMPSON

There are, as you know, many ways to do many things. And one of the best ways to build and insulate electric devices—such as small transformers and reactors—is to mold, or cast, them complete in a solid insulating material, usually plastics. It serves as both the interior insulation and exterior casing (July 1954 REVIEW, page 42).

More and more you see this type of construction. For in recent years the synthetic rubbers and improved casting resins developed by chemists have made it highly feasible. Yet these same materials are organic, being based on the element carbon. When electricity forks across their surface (photo), they break down chemically, leaving a carbonaceous residue. Result: an electrically conducting path called carbon tracking.

And so, while molded, or cast, insulation appeals greatly to engineers, they've usually had to restrict it to equipment utilized for low-voltage or indoor operation. This way they minimize the possibility of arcs flashing over the surface.

A recent discovery, however, now removes this restriction by eliminating carbon tracking in many kinds of molded organic materials. The formulation of molded materials utilizing this discovery underscores a breakthrough into many applications where plastics and rubbers were previously excluded. Even outdoor equipment can be operated at the high voltages of transmission lines without metal outer casings and porcelain bushings.

What Is Carbon Tracking?

Arcs that cause tracking occur in many types of electric apparatus.

Simply opening an electric circuit, even your light switch at home, causes an arc to flash over. Arcs frequently occur on the surface of high-voltage insulators such as the bushings on transformers—most commonly outdoors where insulators are wet and dirty.

Sparking and spitting of high-voltage insulators are common sights on damp days in industrial areas and along the seacoast where the insulator's surface is coated with a film of dirt and moisture. Such surface contamination provides paths of low resistance for electric currents to leak across the insulation. Tiny arcs appear wherever the heat of these leakage currents sufficiently dries out the dirt film to make it nonconducting.

If organic materials are used as the insulator, these minute arcs char the insulation. Little spots of free carbon form on the surface. And carbon being a good conductor, these spots encourage more leakage current. The net effect is like an avalanche: little tracks of carbon progress across the surface at an ever-increasing rate.

Today, engineers refer to this phenomenon as carbon tracking, earlier known as treeing, or burnt tree patterns. It's easy to see why (photo, top right, page 27).

Oxidation as an Answer

Attempts to find organic materials that would resist carbon tracking weren't successful. Even silicone rubber, a semi-organic material containing few carbon atoms, tracked after long exposure to severe arcing. Other approaches—for example, protecting the organic material with an envelope of ceramics or glass cloth—gave no permanent protection. The problem called for an entirely new attack.

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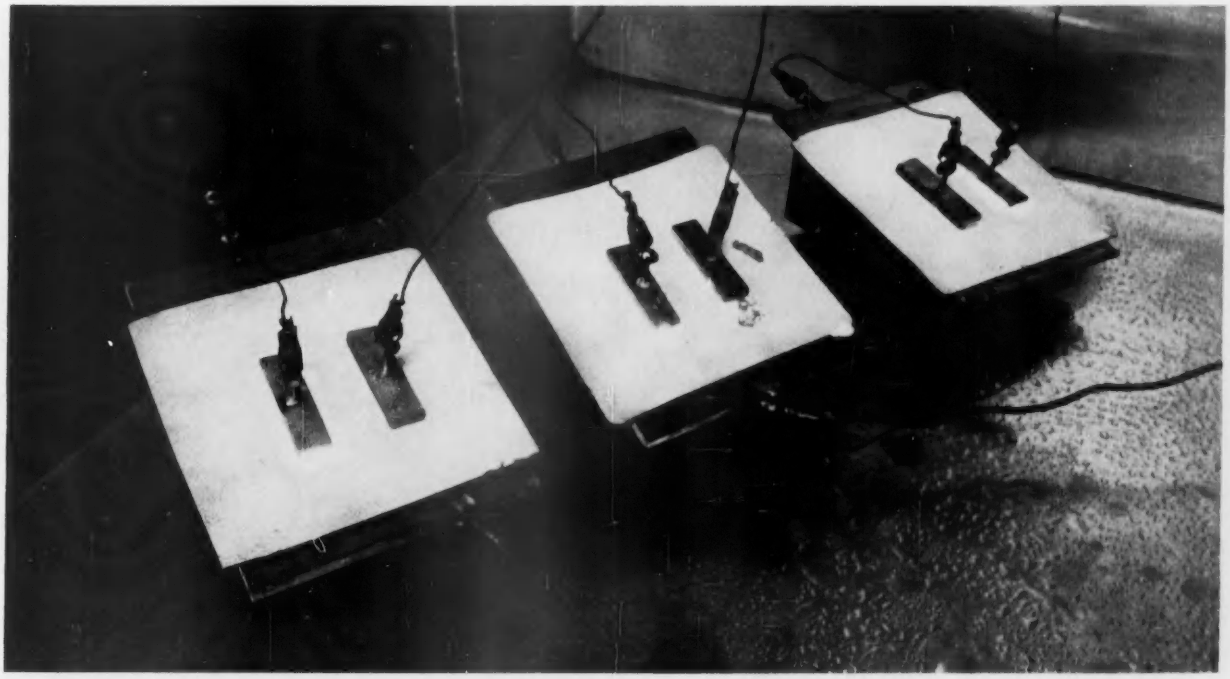
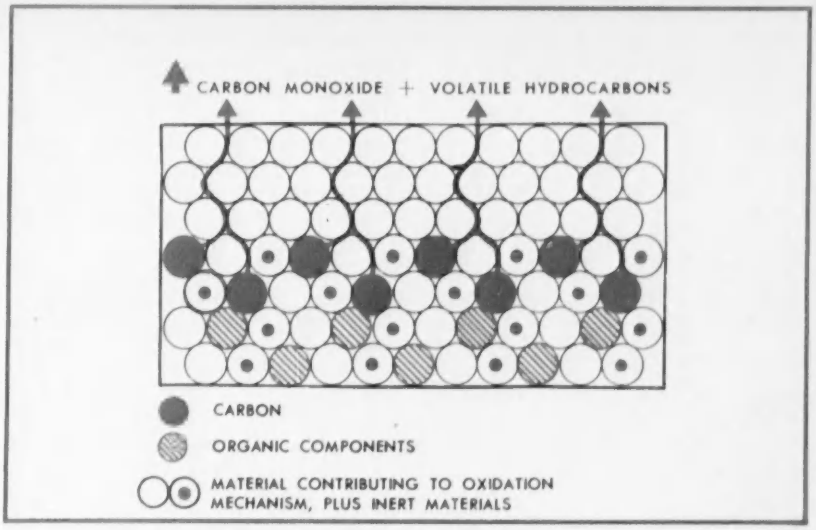
Both Mr. Norman and Mr. Thompson are with the Instrument Department, West Lynn, Mass. They joined General Electric on the Test Course in 1946 and 1939, respectively. Mr. Norman—Manager, Chemical Development, Measurements Laboratory—is concerned with advanced development and application engineering in the fields of electric insulation, organic and inorganic finishes, analytical chemistry, and general chemical problems. Mr. Thompson is Manager, Instrument Transformer Engineering, Instrument Department. He was formerly associated with the Aeronautics and Marine Department and served on the staff of the Manager, Engineering, Small Apparatus Division.



INSIDE FOG CHAMBER, NONTRACKING INSULATION COVERED WITH SYNTHETIC DUST COUNTERS THE FORMATION OF FREE CARBON.



CARBON MONOXIDE AND GASEOUS HYDROCARBONS ARE FORMED INSTEAD OF FREE CARBON.

For three years a basic research program was carried on to find how carbon tracks are initiated in organic materials and, once started, how they are propagated. Results indicated this basic solution: oxidize the chemically combined carbon before an appreciable amount of free carbon forms. The oxidation mechanism, whatever it might be, would of course need controlling. It would go into action only as necessary: namely, when electricity arced across the surface of the insulating material.

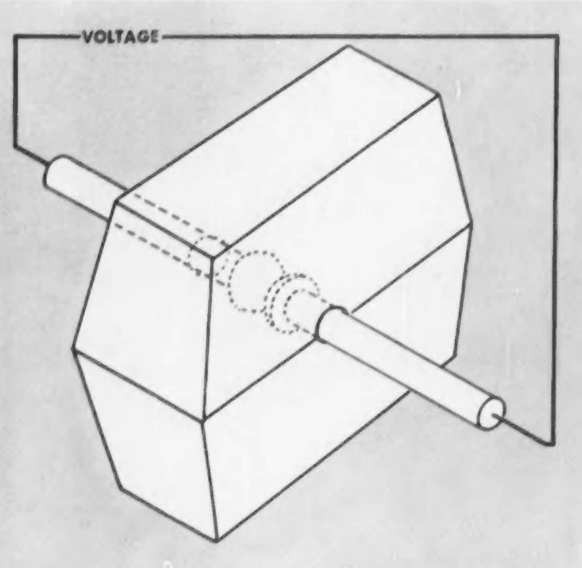
Required next was an additive to provide just such a controlled oxidation reaction when combined with the basic organic insulation. Many materials were tried before the right one turned up.

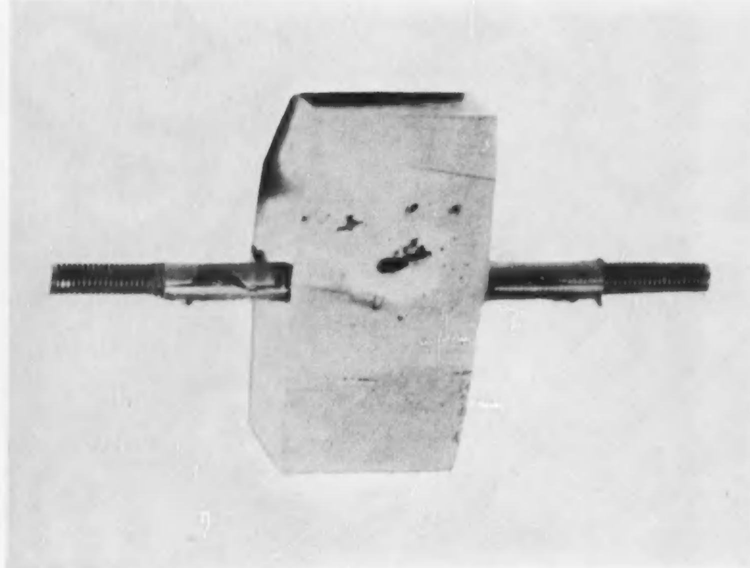
How It Works

The additive material is physically interspersed throughout the base material during compounding. Then, when electricity sparks across the surface, its high temperature breaks down the insulating material's organic components and simultaneously triggers the oxidation reaction. Hydrogen, carbon monoxide, and gaseous hydrocarbons are formed instead of free carbon (illustration). No electrically conducting tracks result. The only effect: random erosion at a slow rate unfocused on any one spot.

The striking thing about this phenomenon is that the oxidation reaction takes place solely within the insulating material, independent of oxygen in the air.

To prove this, two electrodes were molded into a slab of butyl rubber (illustration, left, next page). Then an internal failure, or breakdown, of the rubber between electrodes was caused by applying a high voltage between them. With ordinary butyl rubber (center), the failure charred a conducting path between electrodes, and the insulating material no longer held voltage. But when butyl rubber formulated with the nontracking additive was used (right), no carbonized path formed. The sample continued to hold high voltage between the electrodes, because the cavity formed there filled with gas under pressure sufficiently high for considerable dielectric strength. (This cavity is shown partially cut away in the illustration.)





HIGH VOLTAGE APPLIED TO THE ELECTRODES CAST IN BUTYL RUBBER (CENTER) CHARS A CONDUCTING PATH BETWEEN THEM. BUT WITH NON-

What kind of gas formed? Its composition turned out to be approximately 55 percent hydrogen, 38 percent carbon monoxide, 3 percent methane, and 4 percent ethylene, plus other gases. Results were conclusive. No oxygen could come from the atmosphere which was entirely excluded from the internal failure. Oxygen to form the carbon monoxide had to come from within the insulating material itself. This checked arithmetically, too: the proportion of gases formed tallied with the insulating material's known breakdown products, including the oxygen-supplying additive.

Effective Proof

The next—and logical—question: How effective is this means of eliminating carbon tracks under field conditions? To get more than just an indication, materials and equipment were exhaustively tested under conditions of accelerated and actual service.

THIS ISSUE . . .

of the REVIEW combines the usual May and July numbers and is issued as May-July 1956. The next issue will be September 1956.

Obtaining meaningful results in the laboratory made it essential first of all to develop valid test methods. They had to simulate in accelerated form the contaminated surfaces and types of tracking failures that normally occur in the field. After much experimenting, two such methods were developed, both relying on a dense fog for moisture.

For the first test, the insulating material was a thin sheet coated with synthetic dust to give a conducting film. Two flat electrodes were placed on its surface (photo, page 25). When subjected to fog and voltage, electricity sparked across the material's surface between the electrodes.

The second test, better adapted to equipment testing, utilized a heavily laden salt fog to form the conductive surface coating (photo, right). This test closely duplicates the conditions and results that you encounter in severe seacoast locations, except that failures are greatly accelerated. In fact, so severe is surface sparking in the salt-fog chamber that even porcelain bushings will fail by cracking from thermal shock.

In both tests, incidentally, ordinary organic materials fail by carbon tracking in anywhere from a few minutes to a few hours. However, with the oxidation additive, these same materials neither track nor show signs of tracking—even when tested many hundreds of hours.

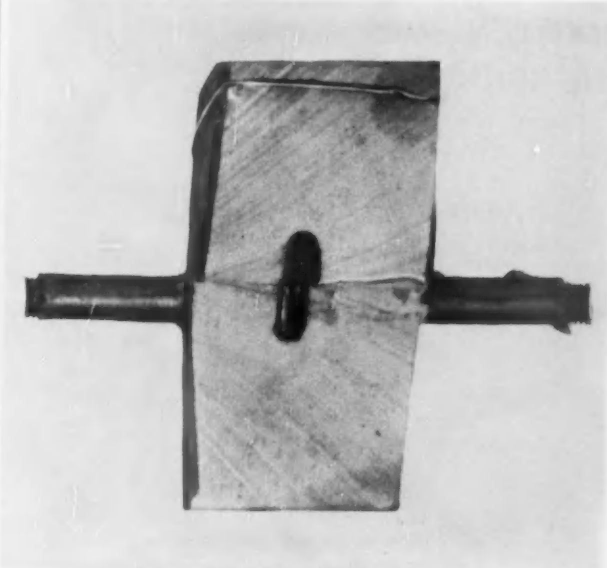
Finally, equipment utilizing the nontracking insulation were installed in areas on the West Coast that encounter severe salt fogs. These operated successfully for over two years with no signs of carbon tracks beginning to form—practical evidence of the nontracking properties demonstrated in accelerated laboratory tests.

Where Now?

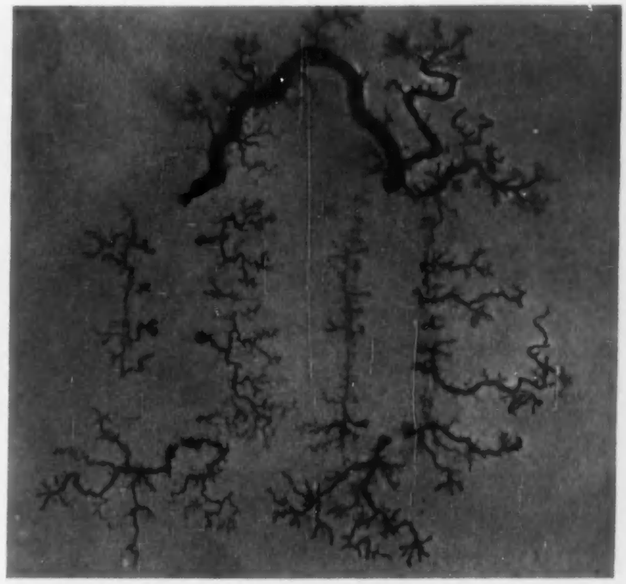
Undoubtedly, nontracking materials presage a major change in the design of outdoor electric apparatus. It's now feasible to extend to larger electric equipments the encapsulation techniques mentioned earlier—the molding or casting processes that have proved of such value in small indoor devices.

Instrument transformers are an excellent example. For several years certain smaller types of these devices have been produced by molding them under high pressure in butyl rubber. All open spaces between the core and windings are penetrated by the rubber. It forms the primary insulation system as well as the external case. When cured, the butyl rubber becomes an extremely tough but flexible material, with excellent mechanical-electrical properties, chemical stability, and long life.

This construction holds manifold advantages over conventional methods of insulating instrument transformers—that is, wrapping them with crepe-paper tapes and impregnating them with asphalt. Molded butyl transformers are not only simpler to manufacture but also more rugged and reliable. And they can be used outdoors without metal



TRACKING INSULATION (RIGHT), NO CARBONIZED PATH FORMS.



BURNT TREE PATTERNS, OR CARBON TRACKS, CHAR ORGANIC INSULATION.

casings to protect them against the weather.

New Yardstick

In the past, butyl-molded instrument transformers for outdoor use were limited to voltages of 5000 volts and below, so that leakage currents could be held low enough to avoid jeopardizing the insulation by carbon tracking. However, the internal oxidation mechanism eliminates this danger, permitting higher voltages. For example, outdoor current transformers in the 15-kv class are now being produced, using a new nontracking butyl insulation. Presently under development are even higher voltage types.

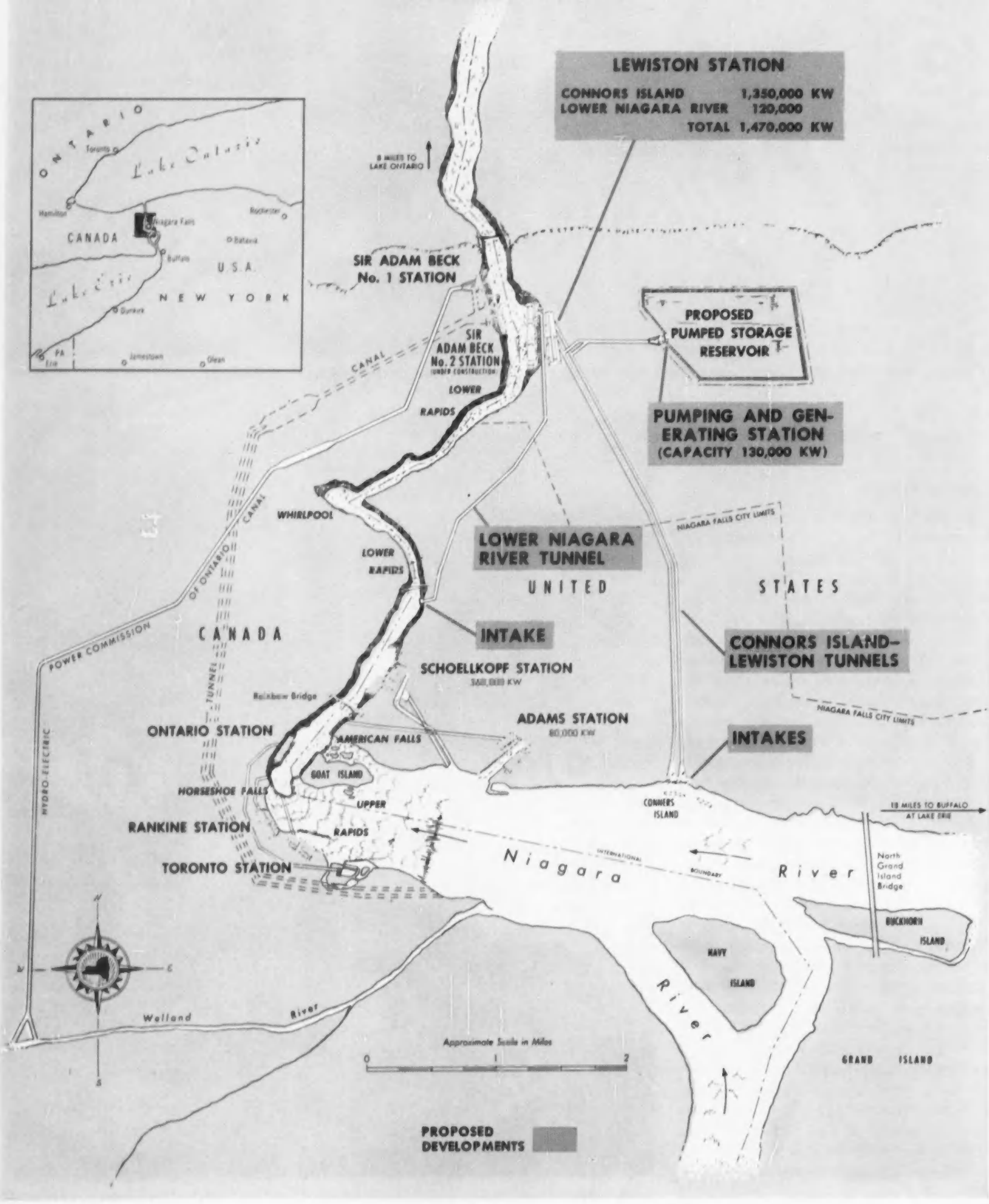
But butyl instrument transformers are only one example of the advantages obtained by molding electric devices in nontracking organic insulations. Other potential applications exist in many types of equipment, including lightning arresters, cutouts, high-voltage bushings, and bus structures. Application to larger equipments—such as distribution and power transformers—hinges primarily on solving the problem of heat radiation to overcome conductor and core losses.

There's little question that the effects of nontracking insulation will be far-reaching. For the electrical engineer now has a new set of application criteria —a new yardstick—for molded organic insulations. He'll be able to use these materials where they've never been used before. Ω

TRANSFORMER UNDERGOES EQUIVALENT OF YEARS OF EXPOSURE IN SALT-FOG CHAMBER.

HYDROELECTRIC GENERATING DEVELOPMENTS ON THE NIAGARA RIVER

(EXISTING AND PROPOSED)



Plan for Developing More Power at Niagara

By HAROLD I. HOWELL

Of all the hydro resources of the world, you undoubtedly think of Niagara Falls as being the greatest and best known. During the past five years, renewed interest in its power potentialities stems from the Treaty of 1950 between the United States and Canada. This treaty permits both countries to utilize additional water from the Niagara River for power purposes, use the water more efficiently, and at the same time preserve the scenic beauty of the Falls.

While Congress has been deciding whether to authorize construction of new generating facilities on the United States side of the river by electric utilities or by federal or state agencies, Canada has practically completed its new development. And she is using our undeveloped share of these waters—permissible under the terms of the treaty, until such time as the United States can use its own share of the additional water.

The American development will coordinate with and extend the present U.S. generating plants, constructed, operated, and maintained by private enterprise for more than 50 years. The history of electric power development by private enterprise at Niagara dates back more than 70 years. Its far-reaching effect has influenced the scientific, technical, engineering, social, and economic advancement of this country and perhaps the entire world—a story already recorded innumerable times.

Let's examine the events leading to the 1950 Treaty and the proposed plan of development by private enterprise now awaiting federal government approval.

Physical Terrain

The 36-mile-long Niagara River (illustration) connects Lake Erie and Lake Ontario and drops 326 feet in its course. Between the outlet of Lake Erie and the Grass Island-Chippawa pool near the brink of the Falls, the river drops about 10 feet in 22 miles (illustration, top, page 31). In the upper rapids between the pool and the brink of the Falls, the river drops about 60 feet in 1½ miles. At the brink the Falls plunge vertically about 160 feet to the Maid of the Mist pool at the very foot. To date, this total drop of 220 feet between the upper and lower pools is the maximum head that private enterprise has been permitted to develop on the American side.

Between the Maid of the Mist pool and the point upstream from Lewiston, NY, the river drops about 94 feet in a distance of 3½ miles. The river drops between the Grass Island-Chippawa pool and the point near Lewiston that awaits economic power development totals about 314 feet in a distance of 6½ miles.

Early Use of River Power

Long ago the power possibilities of the river with the four upper Great Lakes as its reservoir were recognized. Even the earliest settlers used its power when Chabert Joncaire, a Frenchman, constructed a sawmill on the American side in 1757 and operated it by a crude overshot waterwheel. Later, other mills were built but they used only a small part of the 60 feet of head in the upper rapids.

Not until 1853 was a relatively small canal built that cut across the angle formed by the river at the Falls to permit utilizing the 220-foot drop from the Grass Island-Chippawa pool to the Maid of the Mist pool. This headrace canal was acquired at public auction in 1877 by Jacob F. Schoellkopf; he enlarged it and supplied a number of mills with water power. His foresight and leadership eventually resulted in the construction of the present Schoellkopf Station, owned and operated by Niagara Mohawk Power Corporation.

The existing Adams Station, also owned and operated by Niagara Mohawk, began operation in 1895. The success of adopting alternating current produced in this first large central station, plus the proved ability to transmit such power over relatively long distances, marked the beginning of rapidly increased diversions of water from the Niagara River on both the Canadian and American sides.

Treaty of 1909

The public was giving little concern to the possibility that the increasing diversions for power purposes would detract from the scenic spectacle of the Falls and rapids.

But by the turn of the century, an alerted public realized that the rapid expansion of the power development at Niagara might impair its natural beauty.

As a result of this growing apprehension, Canada and the United States made a treaty in 1909, limiting the amount of water that could be taken from the river for power purposes: 36,000 cubic feet per second on the Canadian side and 20,000 cubic feet per second on the American side. With an average total flow of about 200,000 cubic feet per second, this treaty permitted a total diversion for power purposes slightly greater than 25 percent of the average flow.

Developing Power Facilities

An impending power shortage at the outbreak of World War I prompted the Secretary of War to urge the two power companies on the American side of the river to rapidly expand their generating facilities so that complete utilization of the 20,000 cubic feet per second allotted to the United States could be realized. To meet the emergency, additional power facilities were constructed by private enterprise to supply the requirements of the essential electrochemical and electrometallurgical industries at Niagara Falls.

Prior to construction of additional power facilities in 1918, Niagara Mohawk's predecessors submitted various plans of development to the federal government. At that time, an offer was made to develop the full 314 feet of head available for economic development out of the total 326-foot drop between Lake Erie and Lake Ontario.

But this was wartime, and additional power could be delivered sooner by expanding the 220-foot-head Schoellkopf development. The government declared this the best plan and recognized that

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Mr. Howell—Chief System Project Engineer, Niagara Mohawk Power Corporation, Buffalo, NY—has been with the engineering department for 30 years. Presently, he is responsible for coordination of design and construction of new system generating developments.

AT THEIR ADAMS STATION IN 1923, NIAGARA MOHAWK BUILT A SCALE MODEL OF BOTH THE HORSESHOE (RIGHT) AND THE AMERICAN FALLS.

it could form a part of any comprehensive plan for later development. Between 1918 and 1920 this additional development was constructed, consisting of three 37,500-hp hydraulic turbine-driven generators installed in the Schoellkopf Station.

In 1920, Congress enacted the Federal Water Power Act, and soon after Niagara Mohawk applied to the newly formed Federal Power Commission (FPC) for a license. The application included the works then built plus the proposed works to fully utilize 20,000 cubic feet per second under the 220-foot head. Niagara Mohawk also applied for and signified its readiness to construct the full 314-foot-head development if the FPC would grant a license.

After the Commission issued a license in 1921 for the 220-foot-head development, Niagara Mohawk began constructing an addition to the Schoellkopf Station consisting of three 70,000-hp units so that all of the 20,000 cubic feet per second of water allotted to the American side could be utilized at this station. Upon completion of this addition in 1925, the Adams Station (head about 135 feet) was placed in reserve. (During World War II, it was allowed to operate under an additional allotment of water.) The license—the first issued by the FPC—expires in 1971.

The 360,000-kw Schoellkopf Station and the 80,000-kw Adams Station are still the only hydroelectric plants operated on the American side of the river today. These plants utilize about 32,500 cubic feet per second of water in the aggregate.

Preserving the Scenic Beauty

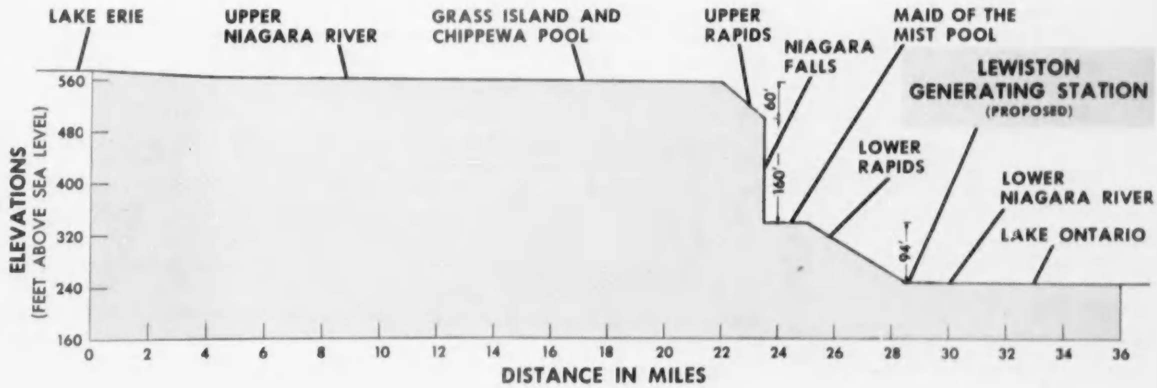
Practially all those concerned with the power business at Niagara generally appreciate that the preservation of the scenic spectacle surpasses all other considerations. More than 30 years ago, engineers of Niagara Mohawk and others who had studied the problem were convinced that additional diversions of water for power would not affect the beauty of the Falls if proper remedial works were constructed.

About 90 percent of the discharge of the Niagara River drops over the Horseshoe, or Canadian, Falls. Gradually through the years, this flow concentrated in the central, or apex, section of the Horseshoe, leaving both flanks depleted of a water supply. Further, as more water was drawn into this central portion of the Horseshoe Falls, the quantity of water flowing over the American Falls was decreasing. An entire cessation of diversions for power purposes from the river would not have retarded this natural change in the shape of the Falls or improved the scenic spectacle. Instead, it would have accelerated the destruction of the Falls.

To demonstrate this reasoning, in 1923 Niagara Mohawk built a large-scale working model of the Falls plus a section of the river upstream (photo).

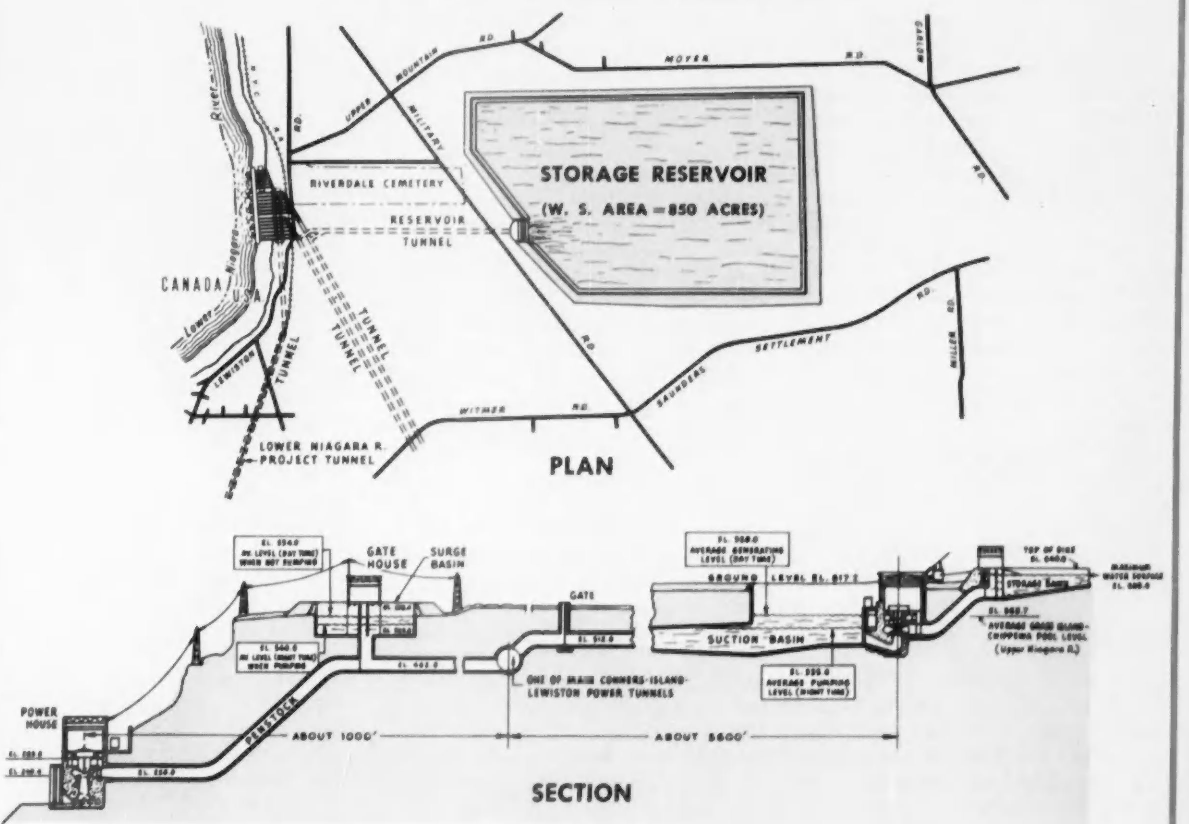
PROFILE OF NIAGARA RIVER

(LAKE ERIE TO LAKE ONTARIO)



PROPOSED NIAGARA PROJECT

(PUMPED-STORAGE AND FULL-HEAD DEVELOPMENT)



"The annual energy will increase by about 8-billion kilowatt-hours...."

So convincing were the experiments that the governments of Canada and the United States appointed a Special International Niagara Board to study the problem and recommend remedial works to be constructed.

The Power Company offered to construct these works jointly with the Hydro-Electric Power Commission of Ontario, using additional diversions of water on an experimental basis. But this proposal, although approved by the Canadian government, was not passed by the United States Senate in 1929.

Treaty of 1950

At the suggestion of Niagara Mohawk to the FPC, a three-party study was initiated in 1947 to further analyze the Niagara situation. This study—carried out by the Commission, Power Authority of the State of New York, and Niagara Mohawk Power Corporation—plus the report of the Bureau of Power of the FPC in 1949 laid the groundwork for the new Treaty with Canada, ratified in 1950.

This treaty is based on a different approach to the problem of limiting the diversion of water for power purposes. The 1909 Treaty limited the quantity of water that could be diverted for power. But the new Treaty specifies the minimum quantities of water that must remain in the river to flow over the Falls during specified hours of the day and seasons of the year to preserve the scenic spectacle. All water in excess of these prime requirements for scenic beauty can be diverted for power purposes, with the United States and Canada sharing equally.

During the daylight hours of the tourist season from April 1 to October 31 of each year, 100,000 cubic feet per second must flow over the Falls at all times. In all other hours of the year, 50,000 cubic feet per second must flow over the Falls. And additional flows over the Falls and through the lower rapids must provide for flushing ice through the gorge when necessary.

The treaty also requires that the United States and Canada complete the remedial works proposed by the Special International Board in 1929 and directs that the work be done under the supervision of the International Joint Commission.

The 1950 Treaty was approved by Canada; but in ratifying it, the U.S. Senate approved a rider stating that any new power development on the American side, as a result of the treaty, must have the approval of the Congress before construction can be started.

Meanwhile, as already mentioned, the Hydro-Electric Power Commission of Ontario has constructed a development to utilize its share of the treaty water plus the U.S. share until such time as we develop it.

The remedial works provided for in the treaty are progressing with those on the American and Canadian flanks of the Horseshoe Falls already completed. The control dam being built to maintain the proper levels in the Chippawa–Grass Island pool is scheduled for completion next year in July.

Proposed Development Plan

The Niagara Mohawk plan of development—joined by four other utilities operating in New York State: Central Hudson Gas and Electric Corporation, Consolidated Edison Company of New York, New York State Electric and Gas Corporation, and Rochester Gas and Electric Corporation — involves four steps . . .

- Construct a 47-foot-diameter concrete-lined tunnel about 5 miles long from the Conners Island intake to the Lewiston powerhouse. This development can utilize about 30,000 cubic feet of water per second under the full 314-foot head and will operate in conjunction with the existing Schoellkopf and Adams Stations. The added installed capacity will total about 675,000 kw.
- Construct a second 47-foot tunnel, adding about 675,000-kw capacity. Schoellkopf Station will continue to operate as well as Adams Station when water is available within treaty limitations.
- Construct the pumped-storage development to provide for greater peak-load output at the Lewiston powerhouse. This development will consist of a single 47-foot-diameter tunnel about a mile long, a pumping-generating station adding 130,000-kw generating capacity, and a pump-storage reservoir of about 22,000 acre-feet (illustration, lower, page 31).
- Construct the lower river development tunnel about 3 miles long and 42 feet in diameter. This will add about 120,000 kw and will develop the 94 feet of head in the lower river between the Schoellkopf Station powerhouse and the Lewiston powerhouse.

This comprehensive plan will add approximately 1.6-million kilowatts of installed generating capacity to the existing capacity of Schoellkopf and Adams Stations. The dependable capacity when utilized in the integrated transmission system of the five power companies will be about 1.1-million kilowatts. The annual energy will in-increase by about 8-billion kilowatt-hours, bringing the total output on the American side to approximately 12-billion kilowatt-hours. This includes Niagara Mohawk's present generation.

The proposed Niagara development can be completed in about six years, and power from the first step can be generated in about three years after construction begins.

The pumping-generating station—an interesting and unique development—was conceived by the Niagara Mohawk engineers about 30 years ago. Because the 1950 Treaty permits greater diversions of water at night when demands for power are less, water will be pumped from the two tunnels that will normally carry water to the Conners Island–Lewiston development into a storage reservoir at night and released the following day through the full 314-foot-head development plus the drop at the storage reservoir. The water wheels of the turbines will act as pumps at night when driven by the generator acting as a motor. The procedure will be reversed when water is being released from the reservoir and the units will operate as generating capacity.

Primarily, the pumped-storage development will permit the generation of about 500,000 kw of peak-load capacity in the Lewiston and the pumped-storage powerhouse in place of a lesser amount of continuous nighttime capacity.

Based on July 1954 construction costs, the complete comprehensive development will total about $420,000,000.

On a kilowatt-hour basis, construction costs for the pumped-storage and the lower river development will be considerably higher than the two-tunnel development from Conners Island to Lewiston. But their construction is feasible, and they form part of the comprehensive plan for developing the Niagara River as long as the cost of comparable steam power would be greater. Ω

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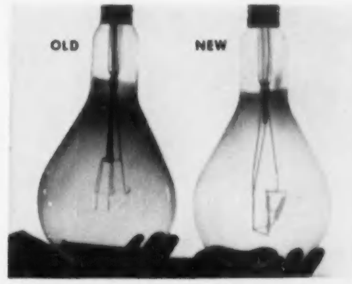

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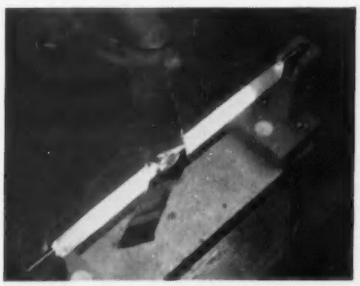
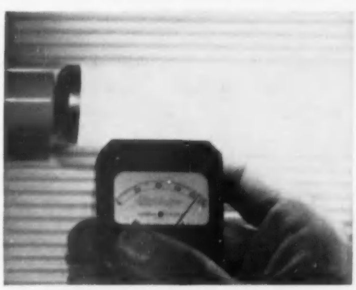

The smallest and hottest electrical heat source available (shown here melting aluminum) the G-E Quartz Infrared permits reduced size in many applications because of the concentrated heat it produces.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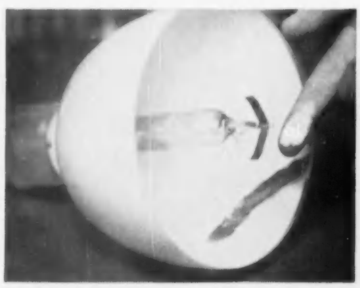
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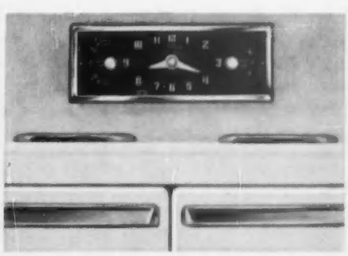

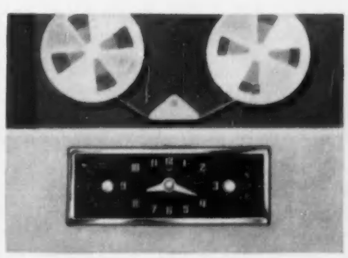

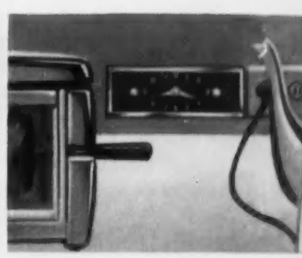

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How to Stimulate Interest in Technical Societies

By J. S. ALFORD

Being professional workers, engineers must bear the responsibility for their own development. One of the most effective avenues of professional development—the technical society—relies mainly on engineers for its support. At the same time, industry must recognize its obligation to provide the engineer with opportunities and encouragement to participate in technical society work.

In modern decentralized organizations, engineers tend to find themselves concentrating on specialized problems. A good technical society breaks down the barriers of specialization and brings its members to a better understanding of each other's problems.

To promote participation in technical society work, efforts should be made to . . .

- Create an encouraging climate and an atmosphere of enthusiasm.
- Promote individual activity among the members.
- Assist engineers in preparing papers and performing committee work.
- Publish information and keep suitable records.

Some progressive companies maintain staff consultants in matters of professional relations. As part of their responsibilities, they work not only with engineering managers to stimulate interest in technical societies but also directly with the societies themselves.

The Climate

Several policies contribute to an atmosphere of enthusiasm for technical societies. For instance, the engineer's employers can pay his expenses at national meetings—expenses that can be burdensome for the individual who has to travel far. Further, a company can sponsor memberships in certain societies and a policy of publicizing society information.

General Electric's Jet Engine Department, Evendale, Ohio, fosters participation in several ways. It pays expenses of those attending national meetings of technical societies. Managers receive bulletins that outline their part in fostering enthusiasm. They are also informed of possible honors and awards, members on their staffs, and how to arrange for Department-sponsored memberships where appropriate.

Membership dues are usually the engineer's expense; but sometimes, when it appears to mutual advantage, the Jet Engine Department will pay. The sponsored engineer should already be a member on his own of one leading society. The Department expects that he will discharge his obligations by accepting committee assignments and preparing papers.

Experience indicates that engineers go to meetings because they're interested in the program and hope that it will contribute to their professional development. No society can flourish without this interest. The Jet Engine Department believes that providing adequate opportunity for continued education has been one of the principal means of stimulating interest in professional development.

Progress has been made in establishing graduate curriculums in engineering at the Evening College of the University of Cincinnati. A registration of 285 engineers at the first session proved the demand for part-time graduate study. In addition, at the Evendale plant, 700 engineers have enrolled in 19 specialized technical courses. Many others are taking such courses as Effective Human Relations, Conference Leadership, and Effective Writing. This enrollment is convincing evidence that engineers have a hearty interest in their own development. The engineers you meet in class are the ones you see at the technical meetings, indicating the correlation between interest in technical societies and an interest in continuing education.

For several years, the Evening College has offered refresher courses to prepare students for the Ohio examination for professional registration. Evendale offers a similar course as part of its Technical Education Program. Judging by the growing number of certificates of registration seen in engineering offices, many engineers make good use of these courses.

Promoting Individual Participation

By attending himself, an engineering manager can most effectively encourage his engineers to go to technical society meetings. Lip service isn't enough. The engineering manager should be present, greet the young engineers, introduce them (nothing is more discouraging than to go to a dinner and speech and sit unnoticed), and perhaps even make up a party to leave from the office together. Most societies require a sponsor for the new member; senior engineers should offer to sponsor anyone interested.

Sometimes the recent graduate needs a helping hand to bridge the gap between college and profession. Many young engineers find it hard to make a transition from their studies in college—where problems are given with only the required data and with necessary simplifying assumptions—to problems in industrial practice where all sorts of complications intrude. The technical society can help close this gap, but the graduate's lack of experience doesn't always permit him to appreciate it.

Reading Papers before the Society

Help is essential in the preparation and presentation of papers before technical societies. First, the engineer must have permission because his proposed paper often relates to Department business. But the engineer can also be assisted in preparing the paper. He can ask a secretary to type it, a draftsman to make slides, and otherwise expect the company to bear part of the expense. Some scholarly journals expect payment for part of the publication cost, feeling that this is as much a part of research as any other.

Occasionally, engineers hesitate to present papers or take part in the discussions because they are nervous or ill at ease on a speaking platform. A definite correlation exists between an engineer's skill in written and oral communications and his participation in technical societies. Engineers themselves recognize the great importance of developing skill in speaking and writing. Undoubtedly the most popular

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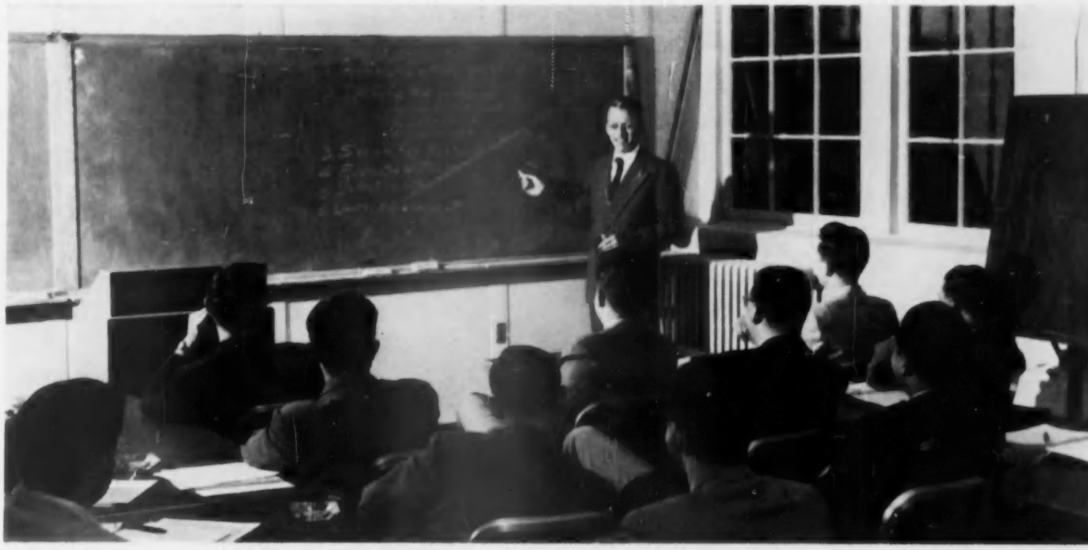
Mr. Alford, a frequent contributor to the REVIEW, *joined General Electric on the Test Course in 1934. Holder of 24 patents, he is presently Designing Engineer, Jet Engine Department, Aircraft Gas Turbine Division, Evendale, Ohio.*



ENGINEERING DESIGN SYMPOSIA

Whenever an engineer in the Jet Engine Department has made a significant achievement, he is encouraged to present this before an appropriate technical society as soon as this can be done without detriment to national security or to the competitive drive that is the mainspring of our industrial progress. However, to provide for timely exchange of classified or proprietary design information, engineering design symposia are held for the benefit of engineers in the Aircraft Gas Turbine Division with the following objectives . . .

Provide for exchange of up-to-date technical information within the Company. As presentations and discussions disclose design details, this information can usually be applied directly to the solution of specific design problems.

Provide for transmitting engineering information coming from outside the Company. For example, most of the Division engineers serving on the National Advisory Committee for Aeronautics (NACA) Technical Committees or Subcommittees also participate in the appropriate engineering design symposia.

Provide for comparison between departments of engineering design methods and procedures. For example, if a particular design approach results in a better solution to a basic engineering problem, this advance is as valuable to all engineers engaged in this specialty as to that engineer who made the contribution. On the other hand, if a particular design configuration or stress level and material resulted in marginal structural integrity or performance, the hard-earned lesson is important to all engineers responsible for new designs.

Provide the integrated knowledge and recommendations of leading individual contributors who have recognized ability and are the best available in each specialty for counsel on engineering design procedures or problems that arise or are anticipated.

The preparation and presentation of material is valuable as a means of professional recognition, as well as a means of increasing the engineer's ability to communicate his ideas. When security requirements have permitted, the material initially presented before an engineering design symposium has frequently been presented before a national technical society.

TECHNICAL SOCIETY COMMITTEES PROVIDE BROAD OPPORTUNITIES FOR THE NEW MEMBER.

course at Evendale is Effective Presentation of Ideas, having 176 members in 16 classes. Each class meets for two hours a week after hours, with considerable homework being required. This course has been popular for the last five years. Its graduates, now much more at home on the platform, welcome the opportunity to appear.

Information and Records

By maintaining thorough records, a company can also foster participation in technical societies. An engineer can't join a technical society or attend a meeting unless he knows about it. Therefore, companies should have all the facts and publish them, either in their own bulletins or by distributing society pamphlets. They should also record the preferences of their engineers —only they know best what contributes to their professional development.

Our Department maintains a counseling service that emphasizes participation by means of brochures and talks. Regular bulletins discuss specific societies, mentioning aims, committees, and membership requirements.

A "Know Your Technical Society Week" organized during October, 1954, received a hearty response in the form of calls for information, as well as a pronounced increase in activity. Many of the application blanks displayed were actually submitted.

Those responsible for planning the week's program used such devices as . . .

- Publicity in the plant newspaper—Jack S. Parker, General Manager of the Aircraft Gas Turbine Division, recommended in an interview more energetic participation plus articles discussing the technical societies cooperating in the Week.
- Displays of literature and application blanks.
- A letter from the president of the Evendale Engineers' Association, endorsing plans for observing the Week.
- Bulletins on honors and awards plus calendars of events.

Each month we publish a plant bulletin titled, "Professional Societies Information," a vehicle for dates and agenda of forthcoming meetings, including announcements of papers to be presented, committee members in AGT, and summaries of reports by engineers who have attended meetings.

Personnel development activities of the plant provides information on awards and honors. Most technical societies make awards, sometimes independently and sometimes jointly, their primary purpose being to encourage contributions to engineering. Awards to younger men spur them on; awards to eminent men recognize achievements.

Some awards are for strictly technical accomplishments, but others additionally require that the recipient must have played a prominent part in his society and be a good citizen.

Recognizing that many good engineers find these awards real incentives, we publicize the established awards in our fields as often as possible. Senior engineers should willingly serve on local awards committees, which screen local achievements for national societies.

Engineering Society of Cincinnati

The Engineering Society of Cincinnati (ESC) has made some interesting use of these principles for stimulating the engineers' interest in technical societies. It has about 1700 members, or three times as many of the next largest group in Cincinnati, and 45 committees. Each new member receives thorough descriptions of the committees and their subjects. Answers to an interest questionnaire usually results in an invitation to join an appropriate committee. ESC feels that an engineer doesn't fully belong until he is a committee member.

Some engineers explain ESC's 45 committees by its large membership, but it's more likely that the membership is large because the 45 committees provide ample opportunity for the new member.

ESC annually greets newly arrived engineers with Newcomers' Night to familiarize them with what Cincinnati has to offer. Each man receives a booklet, "Cincinnati—From an Engineer's Point of View." This well-publicized evening always has a good crowd.

An effective program for stimulating interest in technical society work must provide a favorable climate for technical societies, encourage individual participation, arrange for adequate assistance, and publicize the story. Ω

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48 (lower)	Precision Film Laboratories
53 (upper and middle right)	Douglas Aircraft Co., Inc.
56 (upper right)	U. S. Army
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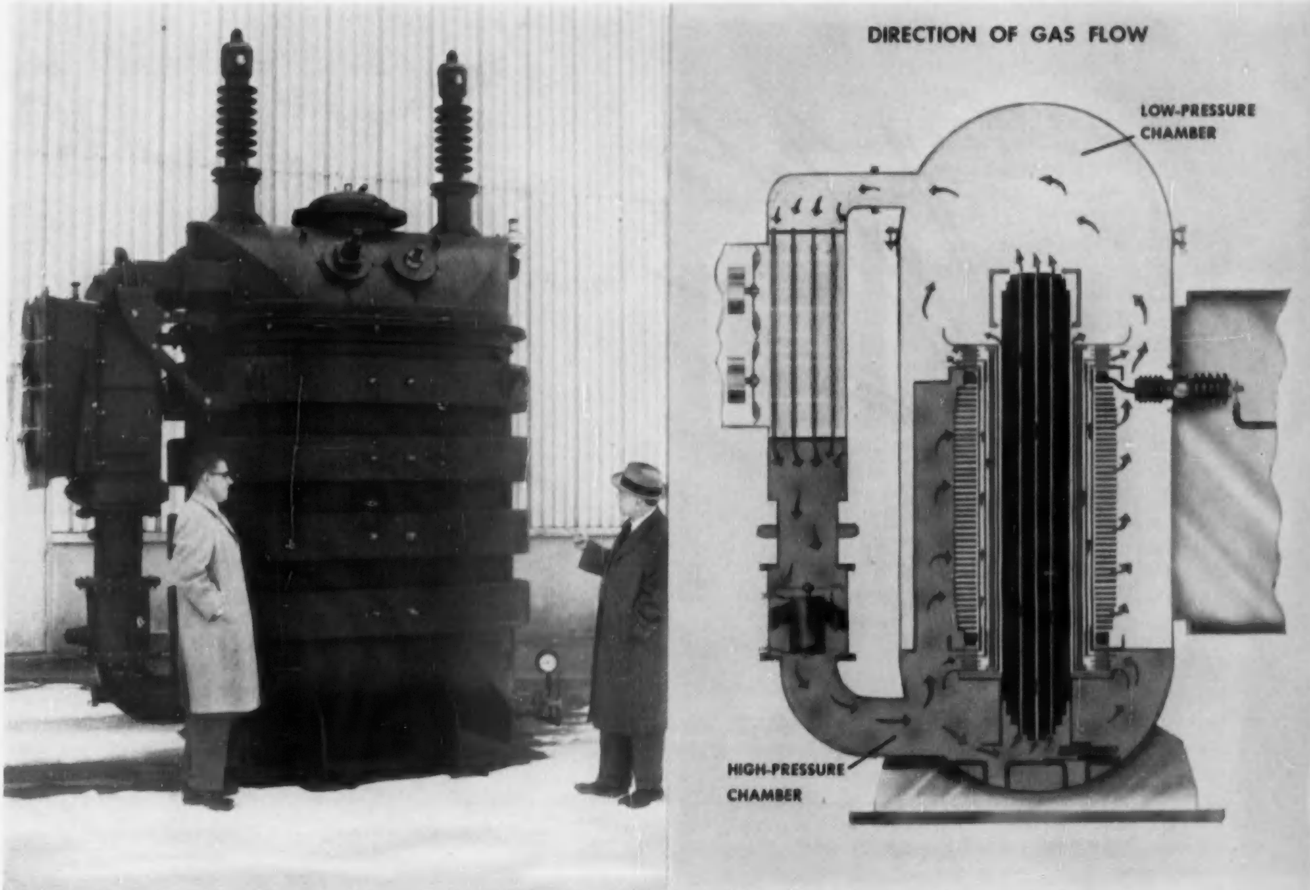


PROTOTYPE OF GAS-INSULATED SINGLE-PHASE 1000-KVA TRANSFORMER IS EXAMINED BY AUTHOR (RIGHT); GAS FLOWS IN ARROWED PATHS.

Gas-Insulated Transformers

By G. CAMILLI

In the minds of engineers who know, there is no question that oil as an insulating and cooling medium made possible the development of modern transformers. In view of this, it might seem to you a bit derogatory to discuss transformers that are cooled and insulated by gas.

Yet oil has two objectionable characteristics: Exposed to flame or heated to its ignition point in the presence of air, it burns; and certain mixtures of oil vapor and air explode on ignition when confined.

When you consider the large number of oil-filled transformers that have given satisfactory service—and the relatively few fires—the use of oil is well justified. It needs no apologies. Because of the possible fire hazard, however, fire underwriters prohibit oil-immersed transformers in certain locations unless they are installed in expensive fireproof vaults. For this reason, dry-type transformers were developed for use in congested districts of large cities.

Synthetic Checkmate

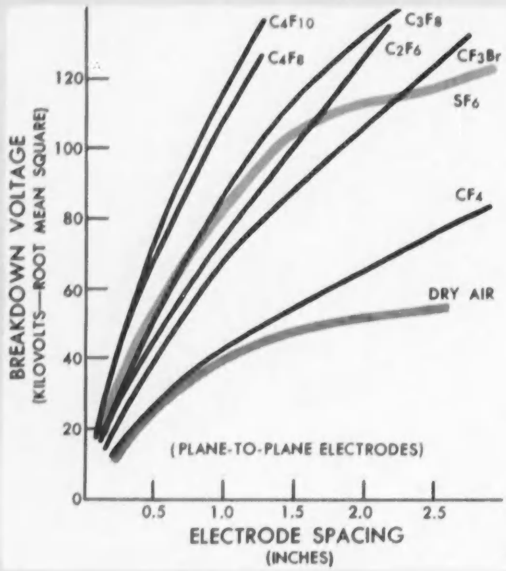
In 1932, Pyranol (registered trademark of General Electric) was introduced. A synthetic liquid, it has all the desirable characteristics of oil plus the distinctive properties of not being flammable or explosive.

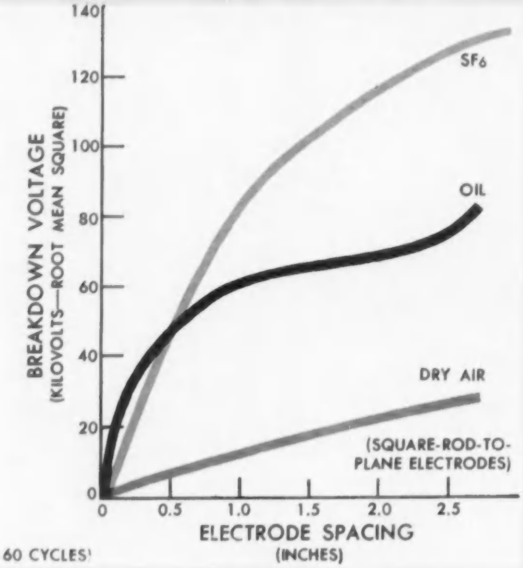
Transformers rated up to 69 kv were built utilizing this fluid. But although they represented a great advance in the art, by necessity they still lacked some of the advantages of dry-type transformers.

For instance, when an internal arc occurs, considerable pressure may be developed as the synthetic liquid decomposes. In some instances this pressure can rupture the confining tank's seams —with the chance that noxious gases will be released.

Insulating with Gas . . .

Substituting gas for the liquid eliminates this disadvantage. Should a failure occur, the pressure would be only a fraction of that developed in a liquid-filled transformer. The reason is simple:





GASEOUS FLUOROCOMPOUNDS have progressed to the point where they now have a fairly high dielectric strength at moderate pressure.

SULFUR-HEXAFLUORIDE SF_6 GAS has a dielectric strength that competes favorably with petroleum-based oil under special conditions.

PROPERTIES OF SULFUR HEXAFLUORIDE VERSUS AIR

Property	Sulfur Hexafluoride (SF_6)	Air
Density (at 21.1 C and 1 atmosphere, pound/cu ft)	0.387	0.075
Theoretical molecular weight	146.06	29.0
Boiling point (degree C)	–62	–200
Viscosity (centipoise) at 21.1 C	0.018	0.0185
Thermal conductivity at 70 C in Btu/hr/ft/degree F	0.00784	0.015
Specific heat at constant pressure and at 70 C, Btu/pound/degree F	0.175	0.24

Pressure from the arcing of a gas is caused only by thermal excitation, probably in a small spot. On the other hand, when an arc occurs inside of a liquid, a large amount of gas forms from the disassociation products.

In the last few years, considerable work has been done to develop gases suitable for high-voltage applications. Gaseous fluorocompounds, for example, especially interest engineers because they are generally inert and have high dielectric strength.

Their development has progressed to the point where gases are now available that have a fairly high dielectric strength at moderate pressure (illustration, left). Some gases that condense at relatively low temperatures are suited to outdoor operation under any conditions of loading. Neither the gases nor their decomposed products are poisonous.

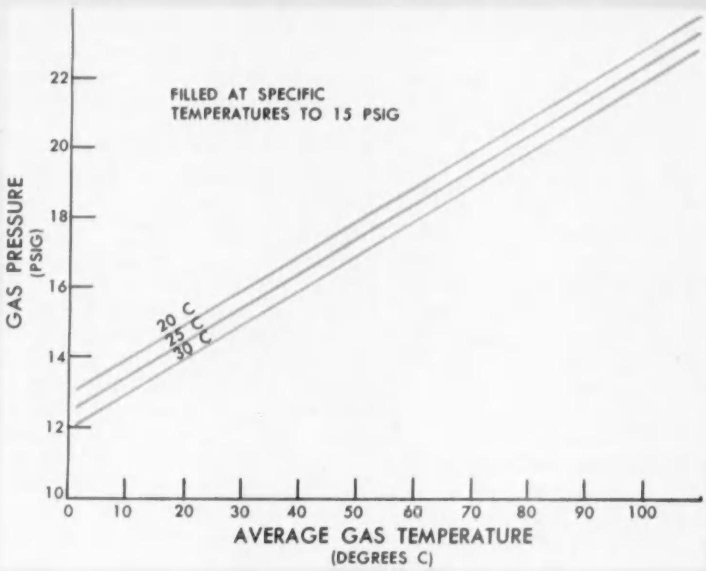
Among these gases, sulfur hexafluoride (SF_6 in illustration) has reached a prominent position. It possesses generally favorable characteristics and is relatively low in cost and easy to obtain. Under special conditions, its dielectric strength competes with petroleum-based oil (illustration, right).

. . . and Cooling with Gas

When you calculate the cooling characteristics of transformers employing fluorogases, you need to make reference to specific heat, thermal conductivity, and density of the gas being considered.

Comparing the properties of sulfur-hexafluoride gas (Table), note that it is many times heavier than air. Because of this, the thermal capacity or heat absorbed by the gas is many times greater than that of air. For absorbed heat is a function of the specific heat times the density of the gas. With sulfur hexafluoride, this product is more than three times that for air.

Accordingly, the temperature rise of sulfur-hexafluoride gas in and out of a transformer would be less than a third that of an air-cooled unit. This would occur where the transformer is cooled by forced circulation of the gas through



PRESSURE OF A GAS varies with its temperature, but the dielectric strength of sulfur-hexafluoride gas is independent of temperature if its density remains constant.

its core and coils under equivalent conditions of pressure, volumetric flow, and heat losses. With forced-gas cooling, using a dense fluorogas or gas mixture, you can dissipate heat at rates equal to or greater than those now set on forced-oil-cooled transformers.

Less Noise

Inside a transformer, vibrations and sound that are transmitted from various sources and emitted to the outside air travel a complex electromechanical route. Simply stated, they follow two principal paths from the transformer's core-and-coil structure to its tank. One path is mechanical: vibrations travel from the core and coils down through their supporting structure to the bottom of the tank. In liquid-insulated transformers, the other path is from the core-and-coil structure through the insulating liquid to the tank.

To minimize the noise and vibration of liquid-filled transformers, resilient mounts have been used between core-and-coil structure and the bottom of the tank. However, vibration and noise find an easy path through the liquid. And you can't appreciably change the impedance of this path without altering the transformer's heat-transfer and insulating characteristics.

On the other hand, in a gas-insulated transformer the transmission path through the insulating medium is poor because the compressibility and the density of the gas is low compared with a liquid.

Of the two acoustical paths mentioned, the vibration of the core and coils in a gas-insulated transformer is transmitted to its tank through the mechanical coupling at the tank's base. By properly choosing resilient mounts for the core and coils, you can materially reduce vibrations transmitted to the tank.

Generally speaking, the noise from a gas-insulated transformer is considerably lower than that from an equivalent liquid-filled unit. In fact, you can sometimes reduce by several decibels the noise that emanates from the core. Total reduction, of course, isn't normally this great because of noise generated by the air blown through the transformer's heat exchangers.

Pressure a Big Factor

To withstand higher than normal internal pressures, the tank of a gas-insulated transformer is designed with as many round surfaces as possible.

For example, the tank of a three-phase transformer has its top, bottom, and ends constructed of cylindrical shells. This type of construction, incidentally, is not new. It is used in Europe for transformers that are transported disassembled. When they arrive at the customer's premises, core and coils are given vacuum-heat treatments in their own tanks to drive moisture from the insulation.

Pressure of a gas varies with its temperature. And if a vessel is filled with sulfur hexafluoride at 15 psig and 25 C, the pressure rises to 20 psig when the temperature reaches 75 C (illustration).

Dielectric strength of the sulfur-hexafluoride gas is independent of temperature, however, if its density remains constant. Thus the dielectric strength of a sealed transformer with gas at 25 C doesn't change when the temperature reaches 75 C—and in this range the pressure varies from 15 to 20 psig.

The heat dissipated by surfaces in contact with the gas is proportional to gas velocity, gas pressure, and surface temperature.

Any change in the operating pressure will be reflected in the tank's design and construction. In other words, a tank is designed for the highest operating pressure so that it won't develop leaks. An increase in operating pressure, on the other hand, might result in higher dielectric strength—or possibly a reduction in the transformer's size.

The velocity of the cooling gas can't be indefinitely increased without serious high-pressure drops. Gas flowing through ducts and heat exchangers causes such pressure drops, which could require large expenditures of power by the blowers that circulate the gas.

Increasing the heat dissipated by a transformer allows you to reduce its size as well as the cooling equipment required. For the gas-insulated transformer, the most effective way to do this is to operate it at temperatures higher than those now used for oil-insulated units.

Stability with Aging

The maximum temperatures at which gas-filled transformers can be operated are limited by the stability of gases you use. Fluorocompounds, with fluorine as the basic ingredient, are the least reactive substances known. When you test sulfur hexafluoride in a quartz container, for example, the gas doesn't decompose even at temperatures up to 500 C. In the presence of certain metals and insulating materials with minute amounts of water, however, the picture changes. Sulfur hexafluoride slowly breaks down at temperatures in excess of 200 C.

As another example, take asbestos. Above 200 C, sulfur hexafluoride is incompatible with this material, possibly because of the water in asbestos. Slowly the water could break down sulfur hexafluoride by hydrolysis to form hydrogen fluoride. This gas in turn attacks the silicate base of asbestos, causing it to lose tensile strength. In this reaction the troublesome water doesn't seem to be simply absorbed moisture. Instead, it is probably molecular water—chemically a part of the asbestos.

Fluorocarbons containing only carbon and fluorine show a lesser tendency to decompose at high temperatures than sulfur hexafluoride. Products of decomposition that result when these gases age are small.

But a large amount of work is being done in fluorine chemistry, and the number of chemical compounds developed increases almost daily. Probably in the near future, you'll see a gas developed that is completely stable at high temperatures.

Toxicity Enters into the Picture

Fluorine compounds are of great interest to engineers in the extremes they show. They range from the least toxic of substances to the most poisonous. As a class, fully fluorinated fluorocarbons are probably among the least toxic of all the known organic compounds.

In applying sulfur-hexafluoride gas to power transformers, two factors have to be kept in mind: the effect of the gas not only on transformer materials but also on the various persons who might be exposed to the gas in high concentrations.

Sulfur hexafluoride is colorless, odorless, and an essentially inert gas. Nonpoisonous, its products of decomposition resulting from electric arcs or continuous corona aren't harmful to the interior of a properly designed transformer installed and operated under typical conditions. And fortunately, neither are these products harmful to people.

You may be interested in the results of tests run at Yale University on the toxicity of sulfur hexafluoride. For periods of 16 to 24 hours, albino rats were exposed to a mixture of 20 percent oxygen and 80 percent sulfur hexafluoride—the maximum concentration possible without diminishing their normal oxygen supply. They showed no signs of intoxication, irritation, or other toxic effects, either during or after exposure.

Assume that the entire volume of sulfur hexafluoride in an average network transformer escapes into a small room the size of a cube, 15 feet per side. In effect, then, the gas would lower the room's oxygen content from approximately 20.9 to 17.9 percent. Now consider a person traveling from sea level to an elevation of 7000 feet. He would experience an even more severe decrease in available oxygen. And so, under the conditions given, no danger of asphyxiation exists.

A Going Concern

Transformers insulated and cooled with gas are no laboratory curiosities. Two units of the type pictured on page 41 are being manufactured for the Consolidated Edison Company of New York. Rated 2000 kva at 69 kv, they have an overload capacity of 140 percent for 8 hours. The transformers are operated with sulfur-hexafluoride gas under pressure of 15 psig at 25 C.

Cooling is accomplished by blowing gas at high velocity through the transformer's winding and core ducts. Circulated by axial blowers, the gas dissipates its heat through two heat exchangers assembled in parallel. So that the gas will be forced through the winding instead of around it, a horizontal barrier is provided at the bottom of the core-and-coil assembly. This barrier, held tightly against the tank's sides, divides the total volume into two chambers: a high-pressure chamber connected to the axial blowers and a low-pressure chamber connected to the heat exchanger. In the high-voltage winding, the flow of gas follows a zig-zag path radially across the coils.

Although some cellulose insulating materials are used in these transformers, tests prove that they aren't combustible—even when the percentage of sulfur hexafluoride mixed with air is reduced to 10 percent. In addition to this, the unit's all-welded construction prevents leakage.

Why Gas-Insulated Transformers?

Why, you might ask, would anyone even bother with gas-insulated transformers when oil-filled units are admittedly good?

In the first place, gas-insulated transformers operate quieter than their oil-filled counterparts. And they are essentially fire-proof and explosion-proof. To engineers not directly involved in the transmission and distribution of electric power, these features may not seem significant. Yet to electric utilities they are of great importance. For the utilities can now place transformers closer to densely populated areas, nearer to the point of usage.

A fireproof transformer has an economic advantage that you can measure in millions of dollars. Presently, underwriters require that oil-filled transformers be located outside the generating station, or powerhouse, unless expensive indoor fireproof vaults are used. This means that a costly system of bus bars located outdoors must carry power from the electric generators to the transformers for transmission. Because no fire hazard is associated with gas-filled transformers, they can be housed under the same roof as the generating equipment, eliminating the expensive bus bars or vaults.

Finally, there are the advantages of lighter weight and low maintenance.

A 2000-kva liquid-filled transformer requires about 10,000 pounds of oil—only 200 pounds of gas are needed to cool and insulate the same size unit. Also, gas-filled transformers need no maintenance.

From a design standpoint, the outlook for gas-insulated transformers is good. The higher the pressure of the gas the better are its insulating qualities and heat-transfer characteristics. And because the dissipation factor increases proportionately with pressure, the transformer's current-carrying capacity may be greater.

And so, while it may seem premature to talk about gas-insulated transformers, they are a development worth watching—one that promises to keep pace with the demand for more and cheaper electricity. Ω

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Mr. Camilli—electrical engineering graduate from the Royal Polytechnic of Turin, Italy—came with General Electric on the Test Course in Schenectady 32 years ago. In 1925, he transferred to the Pittsfield Works where he is presently Supervisor, Advanced Product Engineering, Power Transformer Department. Coauthor of TRANSFORMER ENGINEERING *(Wiley, 1951), he has over 50 patents to his credit as well as two Coffin Awards.*

SOCIETY OF MOTION PICTURE AND TELEVISION ENGINEERS

By DR. JOHN G. FRAYNE

Motion pictures penetrate nearly every area of the contemporary world. Even television, with its comparatively short commercial life, reaches an increasingly large segment of the population. But despite their rapid growth, these media are juniors in the family of communications. Less than 50 years ago the idea of television existed only in the minds of a few farsighted engineers and technicians. Originally, movies and flickers were derogatory terms describing the new moving pictures—their flickering motion disturbed more than the subject matter entertained.

Engineering skill and creativity played a fundamental part in the development of these fledgling industries. But to achieve their present status of influential international media, two other factors were essential: technological coordination and standardization. Progress would have been slow and limited without the exchange of ideas among the men who worked on technological developments in equipment and processes and without the standardization of mechanisms, nomenclature, and practices that guaranteed interchangeability. Although developing rapidly, motion-picture equipment had only one relatively standard item: film—and irregularities existed there.

Early History

Recognizing these needs, a group of farsighted engineers interested in the young motion-picture industry met in the summer of 1916 at the invitation of C. Francis Jenkins, one of the inventors of the motion-picture projector. These pioneers eagerly gathered at the Hotel Astor, New York City, to form an organization that would provide the means for technological cooperation and the machinery needed for standardization. The 25 men comprising the nucleus of the Society of Motion Picture Engineers (SMPE) aspired to " . . . the advancement in the theory and practice of motion-picture engineering and the allied arts and sciences, the standardization of the mechanisms and practices employed therein, and the maintenance of a high professional standing among its members."

To encourage the exchange of technological information, the SMPE held semiannual conventions that provided an opportunity for motion-picture technicians and engineers to read technical papers and talk shop. These conventions soon became musts for the technical men of the industry. To give their papers wider distribution, the Society published the program material in the SMPE *Transactions*, becoming a technical and ultimately a historical reference.

During the 20's, the Society grew rapidly, paralleling technical advancements in the industry. By 1930, membership reached 750. And technological developments such as consolidating sound and picture on one film (photo, lower, page 40) moved so fast that *Transactions* was supplanted by the monthly *Journal* which now appears in a modernized version as the Society's principal publication.

The continual need for new standards and the periodic review of old ones resulted in highly specialized engineering committees. These working bodies organized to carry out the developmental work leading toward standardization.

This growth stimulated the interests of the Society: High-speed photography sessions were included at SMPE conventions; color became a prime topic; and more and more a new word—television—kept popping up in the *Journal*, on convention programs, in technical discussions, and in committee meetings. Television was coming into its own.

SMPE Embraces Television

By 1950, film was used extensively on television. This field involved problems and procedures already familiar to the motion-picture engineer; thus SMPE officially expanded to include the interests of TV engineers. And so the January 1950 *Journal* carried the organization's new name—Society of Motion Picture and Television Engineers (SMPTE).

The two industries greatly influence each other's progress. For technicians, artists, administrators, and writers in both motion pictures and television benefit by sharing their know-how and experience. Through meetings, committees, and publications, SMPTE provides the machinery for this two-way exchange of information.

SMPTE Organization

Motion-picture and television production in the United States centers around New York, Chicago, and Los Angeles—areas containing a sizeable concentration of Society members and forming the hub of local Society activities which fall into three main geographical divisions: Atlantic Coast, Central, and Pacific. Four smaller local areas—Western New York, Atlanta, the Southwest, and San Francisco—form subsections to provide additional opportunities for SMPTE-sponsored meetings. In addition, student chapters are active at the University of Southern California and New York University.

Sections and student chapters elect their own officers, consisting of a Chairman and Secretary-Treasurer, and with the exception of student chapters, a six-man Board of Managers. Sections hold monthly meetings in their key cities, with occasional one- or two-day regional meetings; student chapters hold at least four meetings a year. Section-meeting programs usually consist of papers, panel discussions, demonstrations, and plant or studio tours. For the benefit of those unable to attend conventions, papers are often repeated at section meetings. Nonmembers are always encouraged to come and participate.

Since 1916, national headquarters of the Society has been located in New

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Dr. Frayne, president of SMPTE, has been active in the Society since 1931. He has previously served as editorial vice president and executive vice president.

York City, currently at 55 West 42nd Street. The headquarters staff and the administration of all SMPTE activities fall under the direction of the Executive Secretary. Coordinating the work of the staff and serving as the reporting link between it and the Board of Governors, he is also responsible for implementing the policies adopted by the board and seeing that the principles in the constitution and bylaws are met.

Board members—elected by voting members for two-year terms—consist of 10 officers plus 4 representatives from the Atlantic, Central, and Pacific sections. In addition, the chairmen of these sections serve as exofficio members. The board meets quarterly; whereas the Executive Committee, three or four board members from the New York area, meets monthly with the Executive Secretary to consider control and management questions and to work on any urgent policy problems.

Society Membership

Membership in the past 10 years has grown approximately 15 percent annually. At the end of 1955, membership had increased from the original 25 to more than 5500 technical people in the 48 states and 56 countries. About 5 percent of the members are Fellows elevated to that grade because " . . . by their proficiency and contributions they have attained to an outstanding rank among engineers or executives of the motion-picture or television industries." Fellow awards are presented annually at the fall convention to a limited group, chosen from the Active, or voting, members numbering about 36 percent. Nearly 53 percent are Associates who receive the *Journal*, attend meetings and conventions, and serve on committees but who do not vote, hold major offices, or serve as committee chairmen. Student members, those enrolled in accredited college or university courses, comprise about 6 percent of the membership.

In addition, the Society awarded honorary membership to six outstanding men—Lee de Forest, father of radio; V. K. Zworykin, electronics wizard; Edward W. Kellogg, authority on sound recording; John G. Capstaff, pioneer in the 16-mm motion-picture field; André Debrie, French inventor of motion-picture processing and related equipment; and Walt Disney, pioneer of animated motion pictures—for " . . . eminent service in the advancement of engineering in motion pictures, television, or allied arts."

TV STUDIO DIRECTIONS originate in control room where camera and lighting men can be observed, and actual pro-

More than 100 film laboratories, motion-picture studios, equipment manufacturers, and television broadcasters hold sustaining memberships and support the work of SMPTE.

Conventions

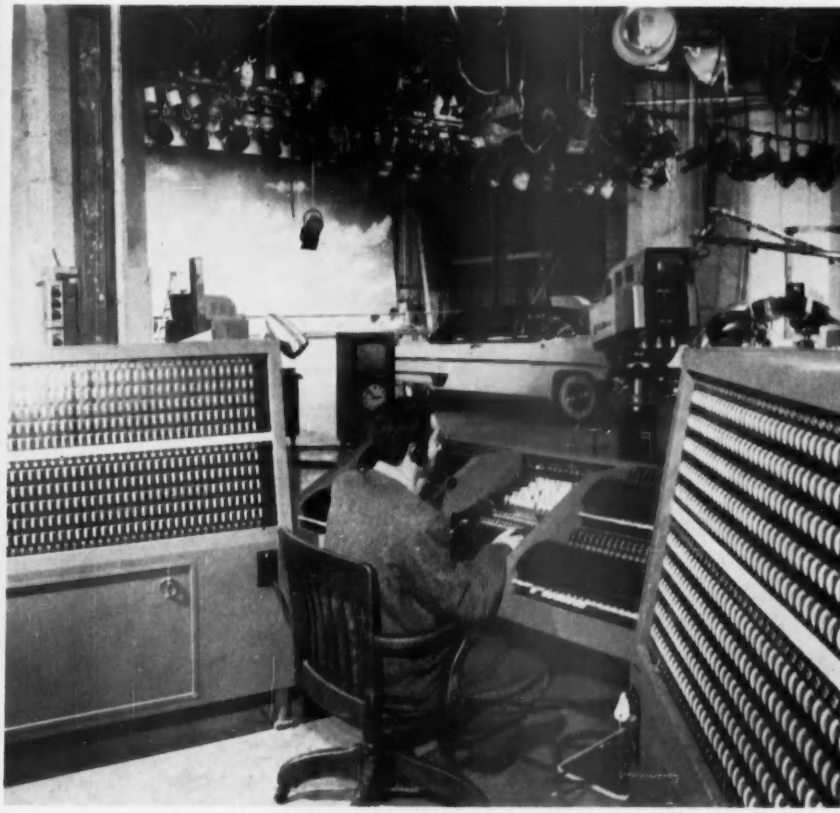
Being a membership organization, the Society makes every attempt to permit active participation of the members in its convention activities. These include the annual five-day national conventions in the spring and fall plus the local meetings. Convention planning comes under the duties of the convention vice president: For handling the practical details of operating a convention, he selects local committees supervised by a local arrangements chairman.

Members find it easy to attend SMPTE conventions, for they usually are held in New York, Los Angeles, or Chicago, with occasional conventions in Washington, DC, or resort areas. Manufacturers and distributors of professional motion-picture and television equipment exhibit their new and improved models at least at one convention a year—the only place where interested personnel can find such a complement of equipment. An exhibit will be included at the next Society convention held in Los Angeles from Oct. 7 to 12, 1956.

Publications

Technical papers, selected for presentation by a Papers Committee, still form the backbone of convention programs. Most of the papers included in the *Journal* come from the conventions. Because members, sustaining members, and some 1500 subscribers receive the *Journal*, this publication tries to cover a variety of interests and technology levels. All papers submitted are reviewed by a Board of Editors for value, accuracy, and interest. The *Journal* averages some 40 pages of technical papers plus 20 pages of service features—advertising, Society and industry news, book reviews, new product announcements, employment service, lists of future SMPTE conventions, and meetings of other engineering and technical societies.

The Society reprints in booklet form papers of unusual interest and value.



grams are viewed both in the studio and on monitors. The complex electronic control console (arrow, left and photo, above) operated by technicians manipulates each lamp individually.

It also publishes special project reports such as a currently available booklet on wide-screen motion pictures and a forthcoming textbook, *Elements of Color in Professional Motion Pictures.*

Engineering Committees

The founders of the Society recognized the need for interchangeability of equipment to assure the industry's progress. The SMPTE's engineering committees were established for this purpose: the development of standards. At present, 14 committees deal with projects concerning color, film dimensions, film-projection practice, high-speed photography, laboratory practice, motion-picture studio lighting and process photography, optics, screen brightness, 16- and 8-mm motion pictures, sound, standards, stereoscopic motion pictures, television, and television-studio lighting.

The committees conduct the research work essential to the development of new American Standards and SMPTE Recommended Practices and carry out the initial steps in the standardization procedure. Upon completion of preliminary work, the *Journal* publishes the proposed standards and invites comments and criticism. The Society seeks to normalize current practice by standardization; although standards are essential to interchangeability, each manufacturer or producer is free to accept, reject, or modify them.

The engineering committees also prepare reports and conduct surveys on subjects of interest to the industry. These reports appear in the *Journal*, which often reprints them.

Activities

The production of motion-picture and television test films—another valuable activity of the Society—is made according to specifications set by the engineering committees and contain top-quality sound and picture material. Test films—used by equipment manufacturers and dealers, theater service and studio engineers, educators, broadcasters, and others—serve as standards for checking equipment performance.

SMPTE also cooperates with other organizations on technical and standards questions of mutual interest. These organizations include American Standards Association, Institute of Radio Engineers, Motion Picture Research Council, National Association of Radio-Television Broadcasters, Association of Cinema Laboratories, Radio-Electronics-Television Manufacturers Association, and Inter-Society Color Council.

The Society participates in another particularly important area: the standardization work of the Technical Committee on Cinematography of the International Standardization Organization (ISO). SMPTE supplied the international chairman, international secretary, and members of the United States delegation to the meetings held in New York in 1950 and in Stockholm in 1955.

Coordination and standardization remain prime objectives of the Society. However, to formalize another activity of high standing, members recently voted on a constitutional amendment adding to the Society's aims—". . . guidance of students and the attainment of high standards of education."

Awards

The Society recognizes outstanding contributions to motion pictures and television and encourages their development by presenting four awards at its fall conventions. The 1955 awards were . . .

- Progress Medal Award—"for any invention, research, or development which resulted in a significant advance in the development of motion picture or television technology" to Dr. Elmer W. Engstrom of RCA for his research and development work in color TV.
- Samuel L. Warner Memorial Award—"for outstanding work in the field of sound motion picture engineering" to Dr. Harry F. Olson of RCA for his work in audio engineering.
- David Sarnoff Gold Medal Award—"for new techniques, methods, and equipment which hold promise for the continued improvement of television" to Bernard D. Loughlin of Hazeltine Corporation for his contributions to the development of color television.
- *Journal* Award—"for the most outstanding paper originally published in the Society's *Journal* during the preceding calendar year" to Richard S. O'Brien of CBS for his paper "CBS Color Television Staging and Lighting Practices," *Journal*, August 1954.

This year in recognition of the achievements of color in motion-picture technology, the Society will add the Dr. Herbert T. Kalmus Gold Medal

PROFESSIONAL MOTION-PICTURE EQUIPMENT CAN GO TO ANY LOCATION—EVEN THE BEACH.

SOUND TRACK AND PICTURE ARE PRINTED ADJACENT TO EACH OTHER ON THE SAME FILM.

Award for major contributions to scientific progress of color motion pictures.

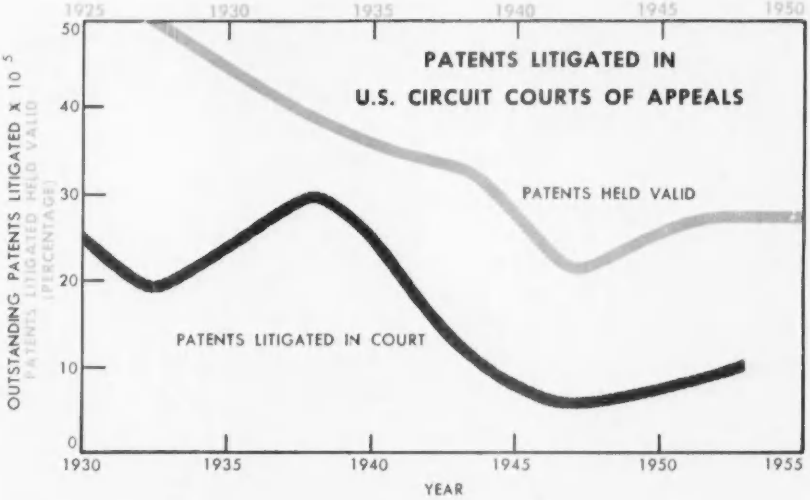
Training and Education

Recently, the Society has become more and more concerned with the increasing need for trained technical people in the motion-picture industry. This twofold need calls for more young, professionally trained engineers to enter the industry and more on-the-job training in modern techniques.

To analyze this problem and make recommendations for meeting it, SMPTE appointed a Committee on Education early last year. This group—representatives of motion-picture studios, labor organizations, television stations, and educational institutions—immediately recognized the need for more technical courses for on-the-job technicians. In cooperation with the University of California at Los Angeles, the first step in the committee's program became effective in September 1955: the addition of three courses—Motion Picture Laboratory Practice, Duplication of Color Motion Pictures, and Illumination Optics—to the curriculum of the Engineering Extension Division of UCLA. Another course, Sound Recording for Motion Pictures, was initiated in February of this year at the University of Southern California. The reception accorded these courses by technicians and engineers evidenced the vast need for and interest in such opportunities. The Society also hopes to initiate similar courses in other parts of the country and broaden its activities to include training for theater projectionists.

Activity flourishes in the motion-picture and television industries. To bring color TV to the general public, engineers and scientists are surmounting many remaining technical problems. The recent development of wide-screen systems and new methods of sound reproduction have improved the quality of motion-picture presentation. However, these add to the many problems of the theater owner, motion-picture producer, and equipment manufacturer.

Theater men today cannot escape the question of standardization. The imponderables: Should the industry decide on one system, or standard? Or are several necessary to meet the needs of various sizes and types of theaters? Whatever the answers, SMPTE will continue to play a dynamic part in their development and in all technological activity so important to the motion-picture and television engineer. Ω



Inventions in the Courts

By H. R. MAYERS

A patent's chances of being sustained by the courts can be investigated in one of two ways. First, compare the patent in detail with a reasonable sample of other patents that the courts have recently acted on; second, evaluate gross probabilities in view of the total recent experience of patents in the courts.

Confining ourselves to a spot check of patents held valid, let's examine the first method. Note that the chief guarantee of a favorable outcome for the owner is the possession of a patent that fulfills a recognized need.

For example, one patent that covers a feather-plucking machine has been sustained in numerous recent litigations throughout the country. Rubber fingers of special configuration successfully defeather a poultry carcass within 8 to 10 seconds. In spite of arguments attacking the quality of the invention, court after court has been impressed by the machine's ability to perform a function not successfully performed by earlier devices.

In another case, a lower court has recognized invention in a process for making rindless Swiss cheese—a product long sought by the dairy industry. In this cheese-making process that produces a normal rind, the invention appears to be in a curing procedure that reabsorbs the rind into the cheese. The court decision notes that in 1952 the patent owner sold 46-million pounds of the new rindless cheese at a price two to six cents above the market price of conventional Swiss cheese—a factor undoubtedly influencing the decision.

In still another case, the court acknowledged invention in a hypodermic injector that successfully injects a measured dose of medication through the skin by direct projection, without the use of a penetrating needle. A chemical reaction produces a controlled, instantaneous pressure within the structure of the injecting device—a practical result of many previous attempts.

Many other examples indicate that, even in the face of impressive attacks on the inventiveness of patented subject matter, the courts have decided in favor of the patent because of a background of existing demand. Of course, prior failures and the obstacles overcome in taking the last effective step toward real success had to be proved.

Naturally, not all inventions involve solving a recognized problem. Sometimes, technical advance necessarily depends on recognizing either the existence of a problem or a potential for improvement. When a patent owner can clearly show one of these qualifications, his chances for a favorable outcome are good.

One case impressively illustrating such a situation brought successful litigation against a major industrial company. The patent owner's invention appeared to reside in merely changing the angle of attack of the cutting blade of a particular milling machine. In its earlier versions the machine was considered satisfactory for most purposes. Thus the need for and possibility of its further improvement were not issues until this patentee, either by insight or experimentation, discovered that a better than 100 percent increase in cutting speed could be accomplished by his adaptation.

A lower court's recent validation of appearance-design patents covering new shapes of chocolate candies illustrates a different application of the power of this principle. Here the inventor, or patentee, conceived of chocolate miniature animals that would enhance candy sales appeal—a conception verified by experience. Clearly impressed by the impact that the patentee's contribution had made on candy sales, a court rebuffed the defendant, who relied on the unlikelihood of invention being found in a chocolate animal's shape.

Infringer's Conduct

The background of the invention is not the only guide that the courts look to in determining the outcome of litigation.

The prior actions of the defendant—the party charged to be an infringer—may predetermine the court's approach, as in a recent case in the soap and cosmetics industry. You have probably seen the shaving lather generated by gas pressure from a can containing soap solution plus a compressed gas of suitable characteristics. A patent on one version of this product was held valid and infringed, in spite of strenuous arguments as to its inherent obviousness in view of prior insecticide spray devices and the like. However, the defendant company had apparently filed patent applications claiming invention in closely similar subject matter and also decrying the effectiveness of the prior art sought to be relied on in litigation—a circumstance the court thought contradictory to arguments made during the lawsuit.

Again, a defendant may contribute to his downfall by too closely or too promptly copying another patentee's minor technical advance. Take, for example, a situation that involved a patent covering a seemingly straightforward change in vacuum-cleaner design: all the design elements were shown

TODAY'S FINANCIAL PROSPECTS OF OPPOSING PARTIES

	Patentee		Defendant	
Lawsuit	Costs	Recovery	Costs and Losses	Savings from Successful Defense
1	$25,000		$25,000	$100,000
2	25,000		25,000	100,000
3	25,000		25,000	100,000
4	25,000	$100,000	125,000	
Total	$100,000	$100,000	$200,000	$300,000

to be used in previously patented applications. The court found the patent valid and infringed, despite the formidable defenses marshaled against it because of evidence of the defendant's intimate relationship to the patentee and his prompt adoption of the inventor's ideas.

All this clearly shows that close attention to background considerations and collateral circumstances is at least as important as the narrow technicalities in forecasting the results of patent litigation. Unquestionably, the increasingly technical character of our society and the mounting backlog of technical literature and know-how have changed the court's attitude and approach to patent cases. However, when the traditional tests of invention are fully met and particularly when the collateral circumstances favor the patent owner, he can expect recognition and enforcement of his rights in a fair percentage of the cases.

But to conclude on this optimistic note fails to give due weight to the facts that confront the person attempting to take the second, or quantitative, approach to patent evaluation.

Statistical Approach

Few patents can be brought before the Supreme Court of the United States, but the initially defeated party in patent litigation can usually have his case reviewed by one of the 10 Circuit Courts of Appeals. Therefore, the action of these courts effectively determines the climate in which patents are tested and held to be valid or invalid. Statistics indicate a colder climate today: From 1925 to 1930, 50 percent of the patents tested at the appeal level were sustained as valid, while approximately 25 percent are currently being sustained.

Viewing the administration of patent properties as a problem in "gamesmanship," let's speculate on the effect that the court's changing action should have on the practice of patent owners in the enforcement of their patents.

In 1930, the patent owner had a one-in-two chance of success in the typical patent litigation. Thus the usual laws of gaming suggest that the prudent operator might have been justified in bringing suit, if in the event of a win his prospective recovery from the infringer was at least twice the litigation cost. Of course, it would have been appropriate to consider not only the prospective recovery from the immediate infringer but also potential recoveries from other infringers whose willingness to come to terms might be favorably influenced by a successful court action. Presumably based on these considerations, a relatively large number of patents were brought to court during the 1920's.

Today's one-in-four prospect of success demands an expected recovery of at least four times the litigation cost. Obviously, the chances of such recoveries are much slimmer. Therefore, under the laws of gamesmanship, the number of cases brought into court should be less under 1955 conditions than those of 1925.

The facts verify this assumption (illustration, page 49). The downward trend in the number of patents brought before the courts correlates with the changing chances of success. The displacement of the two curves (abscissa) suggests that the public requires a five-year time lag to recognize and assimilate the impact of the last five years of court decisions. Presumably, the depression years and World War II account for the erratic behavior of the litigation curve from 1935 to 1945.

For the patent infringer, or prospective defendant, the mathematical game has a slightly different aspect (Table).

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Coming with General Electric in 1930, Mr. Mayers—General Patent Counsel, Patent Legal Services, New York—is a graduate of the Test Course and the Patent Training Program. He holds electrical engineering and law degrees.

Note the patent owner's and the defendant's separate prospects, where the chances of sustaining a patent are one in four but where the recovery in the event of success is at least four times the cost of suit. (The costs indicated may well be exceeded in particular cases.) The Table assumes a series of four similar suits, each on a different patent, and the patent holder can hope to win only one—say, No. 4. Also, only one infringer—and, therefore, only one potential recovery—is involved.

This calculation shows that, while the patent holder breaks even by his persistence in suing, the defendant makes a substantial saving by his persistent defense. All this, however, assumes that the plaintiff, or patentee, prior to suit refuses to settle for a sum less than, say, $100,000—his theoretical recovery in the event that the court sustains his patent. The patentee can reduce the defendant's possible savings and thus make presuit settlement look more attractive by reducing his terms, say, to $40,000—or 40 percent of the theoretically expectable recovery. If the defendant still elects to stand suit, his total costs and losses will remain $200,000. On the other hand, his total costs incurred by presuit settlement would be reduced to $160,000 (four cases at $40,000 each). The $40,000 advantage obviously points to economy in out-of-court settlement.

To assume that each decision to sue or not to sue is based on this kind of mathematical evaluation would be an oversimplification. Bringing suit often reflects emotional or relationship factors not translatable into mathematical terms. Sometimes these lead to legal action, ill-advised economically.

The science of patent law attempts to predict the outcome of threatened litigation with more certainty than the purely statistical approach permits. To the extent that the patent and its collateral facts favorably meet the conditions discussed at the outset, something better than a one-in-four likelihood of its being sustained can be assumed. Conversely, in some situations, adverse factors will so predominate as to justify a less-than-one-in-four prognosis. In a fairly large percentage of cases, however, the patent will be neither appreciably better nor appreciably worse than the average of the patents currently being litigated. Today's figures thus seem to indicate that in these cases the patent owner has roughly a 25 percent chance of a favorable outcome. Ω

ASTM OXIDATION TEST for turbine oils is prepared by the author. The test has been modified in the laboratory to obtain preliminary information concerning the test samples.

Fire-Resistant Lubricants and Hydraulic Fluids

By R. B. McBRIDE

Two recent tragedies—the explosions aboard the aircraft carriers USS *Leyte* and USS *Bennington* in October 1953 and May 1954—illustrate the danger of using flammable fluids in certain types of hydraulic equipment. In both explosions, fluids sprayed from breaks in high-pressure elements of hydraulic catapults were accidentally ignited. Investigations of aircraft accidents over a period of years indicate that a number of aircraft fires might be attributed to flammable hydraulic fluids. The wide distribution of hydraulic equipment in aircraft and the high pressures required to actuate some components constitute a definite hazard.

Industrial users of die-casting and glass-drawing machines, presses, and automatic welders find flammable hydraulic fluids equally hazardous: more than one die-casting machine operator has become a human torch by the failure of hydraulic lines near molten metal.

Today, the development of fire-resistant fluids suitable for this service has vastly improved the problem of fire hazard in hydraulic applications. With several fire-resistant fluids now on the market, interest has broadened to the possibility of using similar fluids for lubricating high-temperature equipment. For example, modern steam turbines operate with initial steam temperatures as high as 1150 F, with higher temperatures anticipated. Accidental discharge of lubricating oil onto hot turbine surfaces could provide a spectacular power-plant fire.

First, let's appraise the term "fire resistant." Virtually all organic fluids, including the fluids we shall discuss, can be burned under some conditions. Accordingly, the commonly used term "nonflammable" is less accurate than "fire resistant."

Paths to Fire Resistance

Petroleum oils—complex mixtures of hydrocarbon molecules—in the viscosity range suitable for hydraulic application have flash and fire points less than 450 F and spontaneous-ignition temperatures of about 700 to 800 F. Halogenation—one well-known method of making fluids more fire resistant—substitutes chlorine or fluorine for hydrogen atoms in a hydrocarbon structure. The perfluorocarbons, one class of materials in this category, consist essentially of carbon and fluorine atoms and are among the most fire-resistant fluids available. However, their extreme high cost and poor viscosity-temperature characteristics have discouraged their use. They have been used where contact with liquid oxygen was likely, a hazardous situation for conventional oils. Partly chlorinated hydrocarbons also have good fire resistance: some mixtures of chlorinated diphenyls have been used as insulating oils in transformers.

Substitution of noncombustible radicals into hydrocarbon structures is another way of promoting fire resistance. Silicones and silicate esters, for example, are expensive but provide a measure of fire resistance. Certain phosphate-ester fluids with good fire-resistant properties have seen considerable service as hydraulic fluids.

Attempts to impart fire-resistant properties to petroleum oils by adding high concentrations of antioxidants, such as diphenylamine, and "snuffers" (volatile materials to reduce vapor flammability) proved impractical due to the high concentrations required.

In addition to the synthetics, fluids containing water as a basic constituent are providing good service in hydraulic applications.

Tests for Fire Resistance of Fluids

No single test can fully evaluate the fire-resistant characteristics of a fluid. Many factors must be considered: volatility, viscosity, heat capacity of the test fluid, presence of air, duration of exposure, temperature, and the nature of the test surface. In 1948 the Society of Automotive Engineers (SAE) established a reference fluid to define the maximum flammability characteristics that could be tolerated for fluids for aircraft hydraulic service.

American Society for Testing Materials (ASTM) flash and fire points (Box, page 52) give some indication of flammability, and spontaneous-ignition temperature tests are useful. However, these tests are not always consistent. For example, benzene's flash point is 12 F, yet its spontaneous-ignition temperature is in the range of 1295 F. Petroleum hydraulic oils have flash points of 350 to 450 F and spontaneous-ignition temperatures from 700 to 800 F.

SOME STANDARD TESTS . . .

ASTM FLASH POINT

The material is heated slowly and evenly in a standard cup, and a test flame is passed across the surface at intervals of 5 F. The temperature of the material when the first flash of ignition appears is the flash point.

ASTM FIRE POINT

The same apparatus is used; the fire point is the temperature at which the oil ignites and burns at least five seconds.

SPONTANEOUS-IGNITION TEMPERATURE

Oil on a steel surface ignites and continues to burn when the surface reaches this temperature.

HOT-MANIFOLD

Fluid is dripped onto a pipe at 1300 F.

MOLTEN-METAL IGNITION

Fluid is dripped or sprayed on molten metal at 1500 F.

HIGH-PRESSURE IGNITION

Spray from orifice at 1000 psi passes through oxyacetylene flame.

LOW-PRESSURE IGNITION

Fluid is sprayed at 100 psi across a rag saturated with burning engine oil.

ARC-IGNITION

Fluid is sprayed through 1.5-inch arc across carbon electrodes.

OXYGEN DEMAND

A flame propagates along a tube filled with fluid mist with the minimum volume of oxygen. Less than 50 percent volume is considered explosive.

FLAME-TRANSFER

Asbestos tape is soaked in fluid and the bottom end suspended in a flame of natural gas and oxygen. Rate of climb is measured.

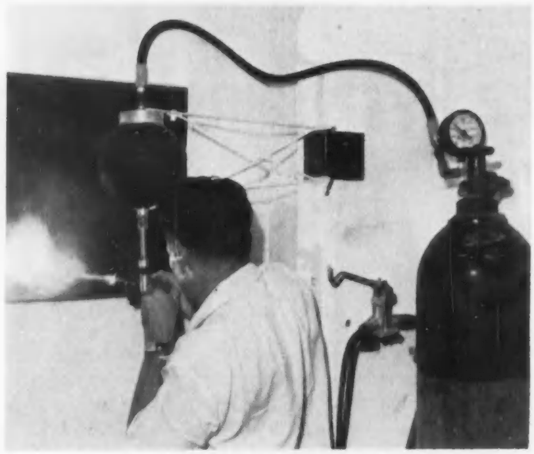
ASTM OXIDATION TEST FOR TURBINE OILS (MODIFIED)

Oxygen is bubbled through the fluid maintained at 203 F in the presence of water plus iron and copper catalysts.

SHELL ROTARY BOMB

A bomb containing fluid, oxygen, water, and iron and copper catalysts is rotated at 292 F for four hours.

HOT-MANIFOLD TEST



HIGH-PRESSURE IGNITION TEST

SHELL ROTARY BOMB

Other flammability tests simulate actual service conditions or measure some arbitrary property on the bench (Box). The Civil Aeronautics Administration (CAA) laboratories have tested hydraulic fluids for flammability in full-scale tests employing a wing section of a B29 bomber and simulated flight conditions. To feign combat conditions, the Naval Research Laboratory fired 50-calibre incendiary bullets into test samples of aircraft hydraulic fluids in containers. With unsatisfactory fluids, explosive ignition of the flying spray resulted from the bullets' impact. Perhaps one of the most revealing tests is a spray-flammability test also developed by the Naval Research Laboratory. This test defines the minimum volume of oxygen that must be present in an oxygen-nitrogen mixture to permit an arc-ignited flame to propagate along a metal tube filled with a finely dispersed mist, or spray, of the test fluid.

What's on the Market?

Let's consider the fluids available commercially for hydraulic use. Several companies now manufacture water-base formulations similar to a fluid originally developed by the Naval Research Laboratory for use in naval aircraft. Essentially, these fluids consist of a base solution of water—which provides the fire resistance—and ethylene glycol. Various additives for establishing viscosity, protection against vapor and liquid-phase corrosion, antiwear properties, and metal deactivation are incorporated into the formulations. United States aircraft carriers now use a fluid of this type for hydraulic catapults.

In 1946, a well-known West Coast aircraft company began development work to obtain a fire-resistant fluid for commercial aircraft use. In 1948, they came up with a new product, the base material being a phosphate-ester fluid. Its widespread use as a polymer plasticizer and a gasoline additive makes tricresyl phosphate perhaps the most familiar phosphate ester. Since 1948, other companies have introduced phosphate-ester-base fluids for use in industrial hydraulic applications.

Presently, water-base and phosphate-ester fluids dominate the fire-resistant-fluid field, though some partly halogenated hydrocarbon fluids are available. Of course, many factors besides fire resistance must be considered in formulating these fire-resistant fluids. In hydraulic service, viscosity is important because pump wear and slippage, power consumption, and response of elements in the system directly relate to fluid viscosity at operating temperatures. Noncorrosivity to ferrous and nonferrous metals and foaming and de-emulsification characteristics are also important. Gumming or sludging cannot be tolerated.

With the commercially available fluids, the chemical nature of the fluids present disadvantages. Water-base fluids, for example, contain ethylene glycol, an excellent paint remover. Used commercially as solvents and plasticizers, phosphate esters attack paints, packings, and sealing materials. The suppliers, however, have acquired considerable know-how concerning materials that are compatible with these fluids.

Oil for Turbines

Turbine operators would welcome a really good fire-resistant lubricant. Steam temperatures of 1100 F have been reached, and 1200 F is considered likely in the next decade. Remember that turbine-grade petroleum oils have spontaneous-ignition temperatures in the range of 700 to 800 F. The necessary fire-prevention devices designed into turbines may add as much as $40,000 to the cost and still not entirely eliminate the possibility of accidents that permit oil to reach hot surfaces.

For some time, our laboratory has surveyed and evaluated possible fire-resistant fluids for turbine use. Except for their fire hazard, petroleum turbine oils are excellent performers.

Any prospective fire-resistant turbine fluid must meet some tough requirements. For instance, viscosity and lubricity characteristics must be adequate to fulfill bearing requirements both with respect to shaft operation at speed and in turning-gear operation. The oxidation and stability must be sufficient to insure that the fluid does not deteriorate when maintained at 150 F for extended periods and subjected to aeration and churning in pump and bearings. Hydrolytic stability (stability in the presence of water) is important because occasionally a turbine must be operated even though water is entering the lubrication system from a defective shaft seal or a leaky cooler.

The fluid must protect the bare metal surfaces from corrosion but not attack protective coatings. To protect the workmen, the toxicity characteristics of a proposed fluid must be considered.

The foaming tendencies of the fluid must be small to avoid erratic behavior of speed-control mechanisms due to air entrainment. These are but a few of the requirements that must be met by a prospective fluid.

Commercial hydraulic fluids mentioned earlier aren't satisfactory for turbine use. The presence or possibility of water entering the system disqualify the phosphate esters because of their inherent hydrolytic instability. Water also helps disqualify the commercial water-base fluids, although design factors more seriously deter their use.

Besides the commercial hydraulic fluids, many organic compounds have been evaluated. The primary screening device is a modified ASTM oxidation test used to evaluate fluids for oxidation and hydrolytic stability, as well as corrosivity, foaming, and emulsification characteristics. An acceptable petroleum turbine oil will pass more than a 1000 hours in this test without noticeable deterioration. Another similar test for these properties is made in the Shell rotary bomb. These and other tests quickly eliminate most fluids.

Tests for viscosity, pour point, and other physical properties disqualify some fluids immediately. Other fluids are so corrosive that no extended tests are necessary. The ASTM oxidation test transformed one otherwise promising fluid into a useless gel in 24 hours.

Prospects

Three experimental phosphate-ester fluids modified to overcome hydrolytic instability and one water-base fluid appear promising in bench tests. Currently, two power companies are testing the modified phosphate-ester fluids in boiler-feed-water pump turbines, and a third company has initiated a test of one fluid in a large turbine-generator unit. Fluid defects have been uncovered in these trials.

The experience gained from these tests will be invaluable in future research and development activities. Successful in hydraulic applications, fluids of this type appear likely contenders for recognition as lubricants for high-temperature equipment. Ω

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With General Electric since 1948, Mr. McBride is a development engineer, Lubricants Sub-Unit, Materials and Processes Laboratory, Large Steam Turbine Generator Department, Schenectady. In addition to work on turbine lubricants, he is concerned with synthetic lubricants, gas turbine and jet aircraft fuels, and plant lubricant problems.

Missile Guidance—Steel Nerves, Steel Muscles

By DONALD E. MULLEN

The human brain, considered the highest general intelligence, is losing out to the more specialized thinking machines in almost all problem areas—particularly in the guidance and control of missiles. Operating with steel nerves and steel muscles, these guidance systems solve the complex problem of directing the right missile to the right place at the right time.

Missiles do not readily lend themselves to a single set of categories. The two basic types of missiles are the pilotless aircraft type, in which electronic and other guidance devices replace a man, and the ballistics, or "wingless," missile—more of the Buck Rogers, or spaceship, variety and the one that will be considered here.

A major category of ballistic weapons is the surface-to-surface (or ground-to-ground) missile, such as the Corporal. Its equivalent in conventional weapons is the artillery gun or, for longer ranges, the bomber.

Another important type—the surface-to-air missile—complements or replaces antiaircraft artillery and interceptor aircraft. The surface-to-air category includes the Nike and other target-area defense weapons, as well as the longer range continental-defense missiles.

The air-to-air missile looks like a sure bet as the primary offensive and defensive armament for most future aircraft. Missiles that fly faster and reach farther than conventional armament are already a reality.

The air-to-surface missile, launched many miles from the target by the carrier bomber, eliminates the necessity of sending a large, manned aircraft directly over the target area.

Other categories of missiles, perhaps slightly more bizarre and difficult to visualize, include the underwater-to-surface and underwater-to-air missiles—naturals for armament of either atomic or conventional submarines. You already know about underwater-to-underwater missiles, or torpedoes. The air-to-underwater missile can be used to combat the enemy submarine menace. As the technology advances, new categories always crop up. For example, surface-to-space or space-to-surface or space-to-space varieties may eventually be considered.

Not a true guided missile, but indispensable to the technology, is the category of research and test vehicles.

Each guided missile could use one or more optimum methods of guidance. The relatively few basic methods of guidance to date offer infinite variations and combinations that defy listing, let alone describing.

Guidance Systems: Preaiming . . .

An easy way to enter the general subject of missile guidance is to back in. One type of modern rocket weapon is not guided but merely preaimed. By knowing where you are, where the target is, and having data on wind and other meteorological conditions, you can aim a rocket just as you would a gun. The Honest John, for instance, is an Army unguided surface-to-surface artillery rocket.

Programming . . .

The next step in guidance sophistication is programming. A timing motor or other clockwork mechanism can be used to guide a missile. A motor-driven cam, for example, can generate a program of deflection of the control surfaces as a function of time, guiding the missile to an intended target. Other functions such as speed, altitude, motor thrust, or other missile parameters can be controlled. Programming is not the smartest type of guidance because unpredictable winds and other abnormal conditions of flight would not be sensed and would produce errors in the missile's path. However, programming is small, light, and reliable, not requiring any form of exterior communication that would advertise its presence or permit the addressee to confuse its control intelligence.

Radio Command . . .

The important category of radio guidance has many variations. One system guides a missile to a fixed target on the surface of the earth. A ground radar monitors the position of the missile as it travels along its trajectory. The data are transmitted to a computer, giving the missile's position and direction; the computer formulates commands to be transmitted to the missile for correcting its course. The data gathered by the radar can represent several quantities and be in various forms.

The more conventional radars measure slant range (direct distance to missile), elevation angle, and azimuth angle, with the possible addition of derivatives of these quantities. The computer in turn can generate commands for transmission that will deflect the control surfaces, adjust the missile's motor thrust, or perform various other functions. The whole idea is to insert a known and stable reference (the ground guidance station's position and orientation) into the guidance equations.

Radar is only so accurate. For a radio system, like any other, has its limitations. Tolerances in components and circuits, as well as atmospheric noise and other variables, produce a certain amount of error in radio guidance systems. The total power required to transmit a dependably strong signal from the ground station to the missile increases rapidly with range. The curvature of the earth, coupled with the line-of-sight characteristics of the radio waves normally used for missile guidance, limits the range of guidance. Refraction, or bending, of the transmitted beam due to atmospheric effects or proximity to surface contours also introduces errors into a radio guidance system. The radio system advertises its presence by radiating energy that can be picked up by enemy monitoring installations. The picture is not entirely black because this

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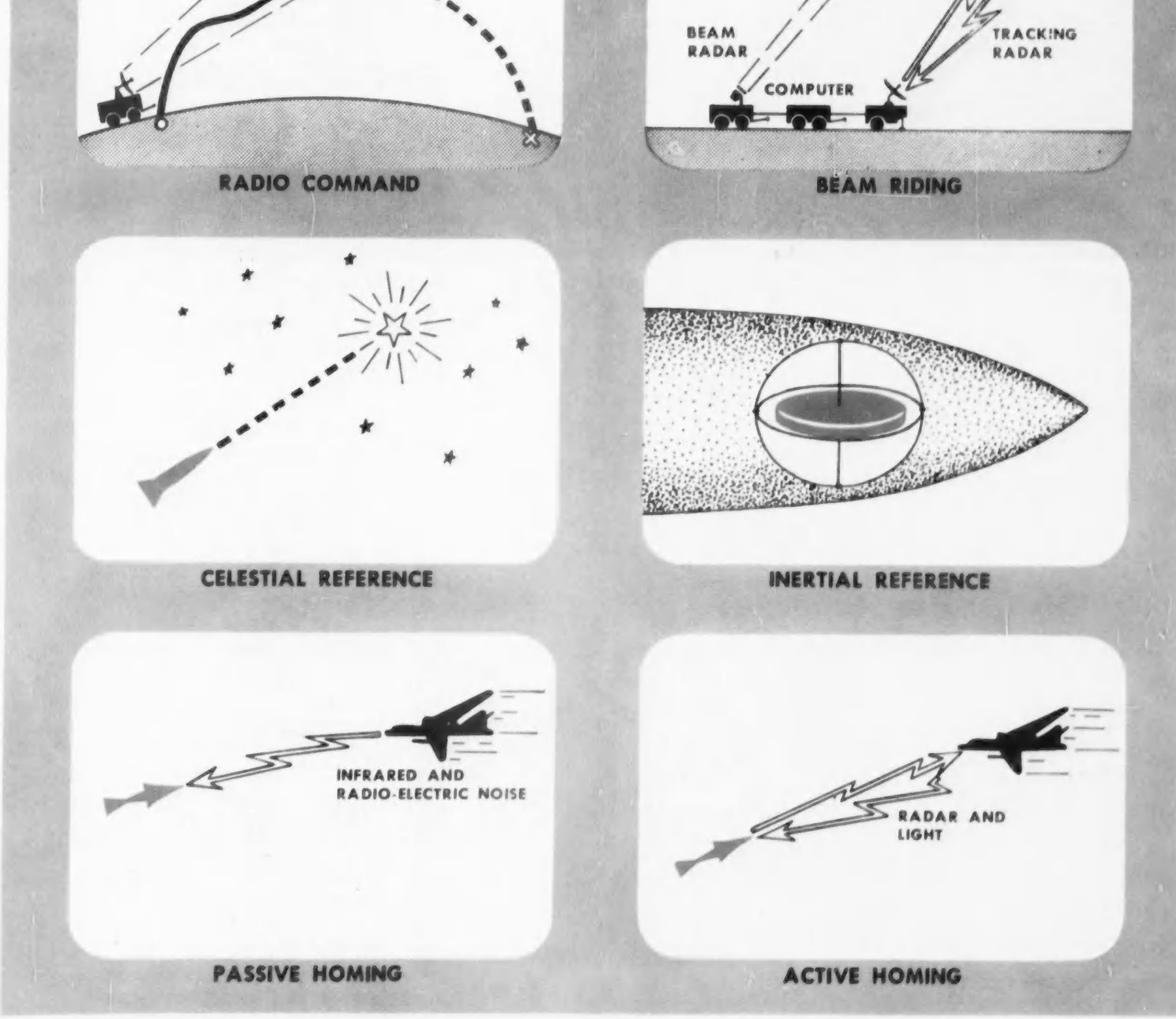
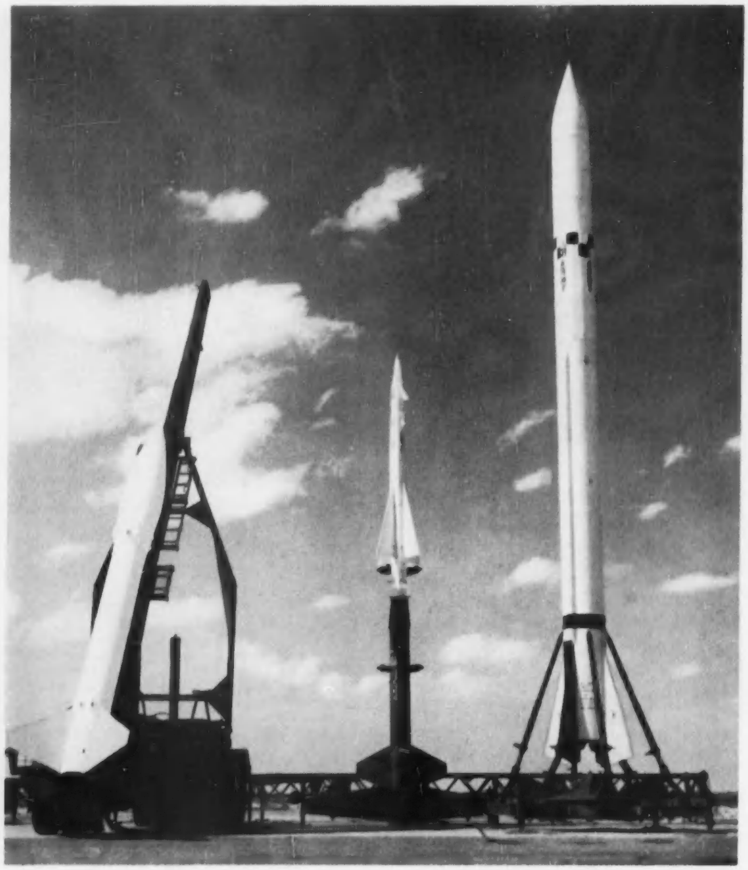
Mr. Mullen—Sales Engineer, Special Defense Projects Department, Schenectady—joined General Electric on the Test Course in 1949. He developed field test equipment for the Hermes missiles, later organizing and supervising missile orientation and training courses for GE and military personnel. Presently he handles his department's sales to the U.S. Army.


PREAIMING
PROGRAMMING
RADIO COMMAND
BEAM RADAR
COMPUTER
TRACKING RADAR
BEAM RIDING
CELESTIAL REFERENCE
INERTIAL REFERENCE
INFRARED AND RADIO-ELECTRIC NOISE
PASSIVE HOMING
RADAR AND LIGHT
ACTIVE HOMING

MIGHTY MIDGET—Falcon guided missile—was developed and produced by Hughes Aircraft for USAF.



MISSILE FAMILY developed and produced by Army Ordnance includes Honest John (left), an artillery rocket, and Nike (center) and Corporal, both guided missiles.

GROUND-LOCATED RADARS developed for Army Ordnance installations form an essential part of the beam-riding missile guidance system by directing the Nike to its target.

guidance method permits leaving much of the guidance equipment at the ground location rather than in the missile. Further, by means of radio guidance, the launching-battery commander always knows the location of the missile. Intelligent use of radio guidance—knowing and respecting its limitations—produces an effective guidance system.

Celestial . . .

Another basic type of guidance is celestial reference. The art has produced devices that can track stars or other celestial bodies automatically—another specialized method of establishing a known reference in the missile guidance system. Rather than radio energy, the missile receives light energy, also having limitations. This system is effective only "over the weather," because cloud cover or other weather phenomena would block the light source—stars. And, conceivably, someone could produce an artificial and distracting light source that might confuse the star tracker. All in all, it appears to be a unique method for missile guidance or, more properly, navigation—undoubtedly, the prime navigation reference for the first rocket to Mars.

Inertial . . .

One method receiving considerable attention today is inertial guidance, essentially celestial. For many years we have known that a perfect gyroscope can give a reference fixed to the average position of the fixed stars. In other words, a gyroscope is a device independent of the earth's motions. Thus the creation of a gyroscope reference forms a self-contained celestial reference in a guidance system. This reference is perfect only as the gyro is perfect. In the last five or six years, significant advances have been made in the gyro art, and more are expected. This unconventional field presents conventional problems: tolerance, friction, dimensional stability, and others.

With the gyroscope furnishing the direction reference, a device known as an accelerometer measures motion in the known coordinates. Starting from a fixed location, such as the launching site, this combination of instruments measures certain components of the missile's acceleration. The inertial system then does some mathematics, performing the equivalent of a double integration, and computes distance traveled.

Entirely self-contained, inertial guidance neither radiates any energy nor responds to any external energy. Except for testing and adjustments, no ground guidance equipment is required.

Within these basic categories of guidance for surface-to-surface missiles are many variations and combinations. For example, radio guidance over a first portion of the trajectory might be the best choice—the transmission path is short and the signal strength good. Probably the enemy would have a difficult time jamming the radio command link near the launching site. Then, part way along the trajectory, conversion to inertial guidance might be wise, thereby eliminating radio command links over the extended ranges of the missile. With that as a starter, all manner of combinations can be conjured up from the building blocks just discussed.

Homing . . .

The other predominant mission of guided missiles is the antiaircraft, or surface-to-air, category—basically different from surface-to-surface because the target is not fixed. Instead of getting all the ballistic constants and missile computer settings from maps and firing tables, a tracking radar or other device is required to monitor the location of the target.

The first and most obvious solution to the moving-target problem is a homing device using elements that will sense light, noise, heat, and radio transmissions. If the target produces any of these energies, the missile guidance unit can home on the signals and direct the missile to the target. Because no other except natural emanations from the target are required, this general family of guidance systems is called passive homing.

A slightly more complex, semiactive homing scheme tracks the scattered reflections from the target. Some form of energy radiator, perhaps a ground search light, radar set, or similar device, is located nearby to illuminate the target. Because of the control over the radiated energy, the device can be made selective. And the total radiated energy level for the missile to track can be increased.

In the active homing system, both the illuminator and the homing device are located in the missile. The principle of operation is no different from any other.

Homing systems cause the missiles to fly on a homing course that may not be the most efficient or effective for intercepting the target. If the enemy knows the characteristics of homing systems, he can develop optimum evasive maneuvers to avoid interception. The speed of the antiaircraft missile, however, considerably protects against this defensive maneuver.

. . . and Beam-Riding

Another surface-to-air guidance method is a beam-riding system. The missile guidance device is designed to steer the missile so that it will remain in the center of the radio beam being transmitted from the ground. This beam can be positioned by commands from a computer furnished with target data. With this equipment, it is possible to lead a target and to compute collision or "intercept" courses to fly, which are more efficient than "homers." The main disadvantage compared with the homing systems lies in the additional complexity of the equipment.

Radio command systems similar to those used for surface-to-surface weapons can be employed in the antiaircraft missile. Missile commands are computed from target data and transmitted to the missile. The command intelligence, not the beam position or other conditions, maneuvers the missile.

Let's turn now to the unique characteristics of guidance. Any missile guidance system must perform all the needed functions for a given mission in a peculiar way and under trying circumstances. For example, one simple system might . . .

- Maintain the coordinate system reference
- Determine missile location and direction in three-dimensional space
- Compute or receive and act on corrective commands
- Measure and compensate for varying flight conditions.

Guidance equipment in missiles submits to extremely severe environments. Temperatures inside the missile range from the cold of liquid oxygen to the heat of the motor combustion chamber. Problems of skin friction and heating continually plague the missile guidance experts. The magnitude of steady-state acceleration, vibration, and shock is worse than those encountered in manned aircraft or other instrument applications.

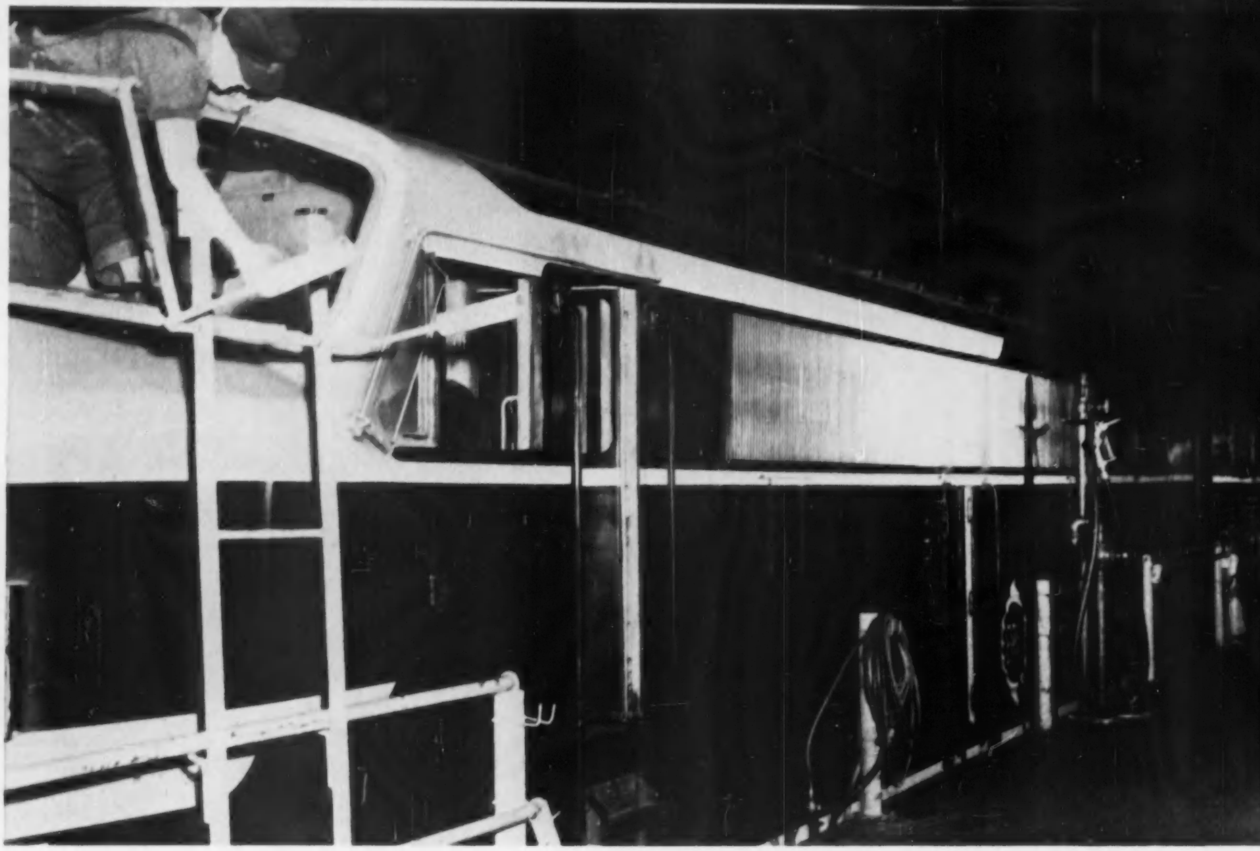
Still another problem confronts ballistic missile guidance experts: maneuvering within an amazingly short period—a magnitude of seconds. Once launched, the missile climbs rapidly into the stratosphere. For much of the remaining flight, the air is too thin to produce steering forces on the control surfaces of the missile. For the same reason, external disturbances cannot appreciably affect the missile's path.

On the way down, a portion of the second short maneuvering period may be used just to recover from the high-speed re-entry into the dense air. At high Mach numbers, this can be compared to missing your timing on a full-twisting 1½ dive from the 3-meter board.

Thus you see that the guidance system must surmount the serious obstacles of numerous functions, severe operating environment, and limited operating time. And it must be tactically usable under harsh field conditions by modestly trained troops—who may well be wearing arctic mittens at the time.

Progress—the combined result of genius, sheer manpower, and vast sums of money—is being made in missile guidance systems despite all these disheartening obstacles.

Guided missiles, already unbelievably smart, tough, and unemotional, will be even smarter tomorrow. Ω



1 For final grooming of the diesel-electric locomotive before its run, energetic Erie shop men wash down each unit; fuel it; check brakes and air lines; and make a general inspection before dispatching the locomotive to the yard for coupling to the train.

2 Hand on throttle, hostler prepares to move the million-dollar development locomotive out of the diesel shop to the ready track for its train.

3 On the ready track at last, the 6000-hp locomotive waits for its crew in the predawn gloom. The run is 400 miles from the Erie yards in Marion, Ohio, to Hornell, NY, but each crew will ride only two divisions, or 200 miles.

Erie's Friendly Locomotive

By D. N. ABOUDARA

I first saw the 750 at dawn one fall morning on the service track in the Erie Railroad yards at Marion, Ohio. Its diesels were warming for our morning run. Told to report in good time to help with the preparations, I climbed into the cab and introduced myself to the crew.

The days following proved that the crews really live up to Erie's slogan, "The Friendliest Railroad." By the terms of the agreement between General Electric and the Erie, who operate this development locomotive, the crews technically are not responsible for G-E observers' extra comforts. Yet time and again they went out of their way to help us and make us comfortable.

For instance, one morning I was so rushed with helping to prepare the locomotive for the road that I missed breakfast. A five-minute stop scheduled in Salamanca, NY, wouldn't allow time to order and eat a breakfast. John Davis, the brakeman, suspected my plight and phoned ahead. When we pulled in, a yardman presented me with the best-looking food I'd seen in some time.

When I first began riding the 750, I was pretty ignorant of railroading. On the first run, I was left behind—or so I thought in a moment's panic. When we stopped at Kent, Ohio, I wanted to get something to eat. The engineman told me that the train would be there about 20 minutes and promised to warn the new engineman that I was at the grub shack.

When I came back 10 minutes later, the 750 was gone. Horrified, I had visions of being marooned in Kent and, worse, having to explain to my boss why I wasn't on the last half of the run.

Two minutes dragged by before I saw a familiar locomotive backing down the track. She had gone to set out a few cars from the train, but I was too green to think of that.

I learned fast, though, because I didn't want the reputation of being a tenderfoot. I soon was able to read block signals and to understand the crew's shoptalk. Once, if Davis had said, "Last night we had a kicker and went in the big hole," I would have had to ask for an explanation. Now I know that when the engineman lightly applied the brakes, a mishap caused the emergency brake to operate all down the train, bringing it to a sudden and unceremonious stop. I learned not to step on a rail, for you can slip and crack your skull on the opposite rail. And a blue flag or light attached to the head of a train means that a locomotive must not be coupled to it; someone is working on it—around the cars or inspecting the train. Only that man can remove the signal when he is through.

One winter night we left Hornell in 10-below-zero weather. The superchargers drew great quantities of arctic air into the cab. The crew warned me not to touch things carelessly for fear that my hands would freeze tight to them.

As I was checking load distribution among the four engines, I found that the engine in D unit was protesting about taking load. Because the crews were unfamiliar with this new locomotive, it was my responsibility to find the trouble and fix it; I grabbed tools and a pair of work gloves to protect my hands from the cold fittings. I found the trouble easily: a slight binding in the linkage between the engine governor and the injection-pump rack cut down the fuel injected and consequently the horsepower output. I reported to the engineman and asked him if he would need all the 750's 6000 hp during the rest of the run. He shot right back: "You remember the one percent grade outside of West Salem that I told you about? We'll be there in a few minutes, and we'll need all four units to make the top." "OK," I replied. Going back to the engine in D unit, I prepared to sweat out the rest of the trip. As we hit the grade, I gave the fuel rack the little extra boost necessary, and the engine roared as usual. It was thrilling to hear the diesels settle down and talk turkey as they hauled our 6500 tons up that grade at 15 mph.

That's what it's like to be a railroad observer—always something going on, with some acute excitement now and then. And there's no better way to learn railroading. Ω

PICTURE STORY CONTINUES ON NEXT PAGE

4 Joining the crew, author Aboudara (right) has several minutes' intensive work to do before departure of the 750. Aboudara joined GE on the Test Course in 1950. Leaving the Company in 1952, he was employed by the Food Machinery and Chemical Corporation, San Jose, Calif., until 1953 when he rejoined GE as a Transportation Specialist Trainee in the Locomotive and Car Equipment Department, Erie, Pa. Presently, he is Transportation Specialist with the Company's Apparatus Sales Division, San Francisco Office.

5 With the No. 750's diesels working at full throttle to accelerate the 120-car freight, Aboudara begins recording essential performance information. On a typical run, the observer takes about 8 pages of engine data. These plus facts and ideas will aid the designers in creating future locomotives.

Erie's Friendly Locomotive (CONCLUDED)

6 No. 750 thunders swiftly through a whistle stop in New York State without slowing down. Railroad crews have been known to vigorously scold motorists and truckers with the airhorn for racing at grade crossings.

7 Old timers who work along the line expect much of the locomotive. Crews who have not operated it have heard of its performance. Once, a fault in the automatic-sander circuit poured sand over a new switch in front of a group of Erie officials inspecting the yard. And switch sanding is a cardinal sin in the railroader's book. But G-E field engineers corrected the fault almost before the story could travel up and down the line.

WHY A DEVELOPMENT LOCOMOTIVE?

To develop and prove components of complete reliability for locomotives intended for overseas service, GE's Locomotive and Car Equipment Department needed a development locomotive in an assignment tough enough to work every component harder than it could be worked in any out-of-the-way corner of the world.

This 6000-hp locomotive is divided into four sections, permitting the power to be matched to the train—no wasted capacity here. The fluted side sheets of this tough locomotive provide the low weight and rigidity needed for its demanding task.

The diesels are Cooper-Bessemer, four-stroke cycle, and turbosupercharged, with the 1800-hp engines being V-12s and the 1200-hp engines, V-8s. Each is directly coupled to a d-c generator of the latest design. Traction motors, one on each of the four axles per unit, are geared for 65 mph.

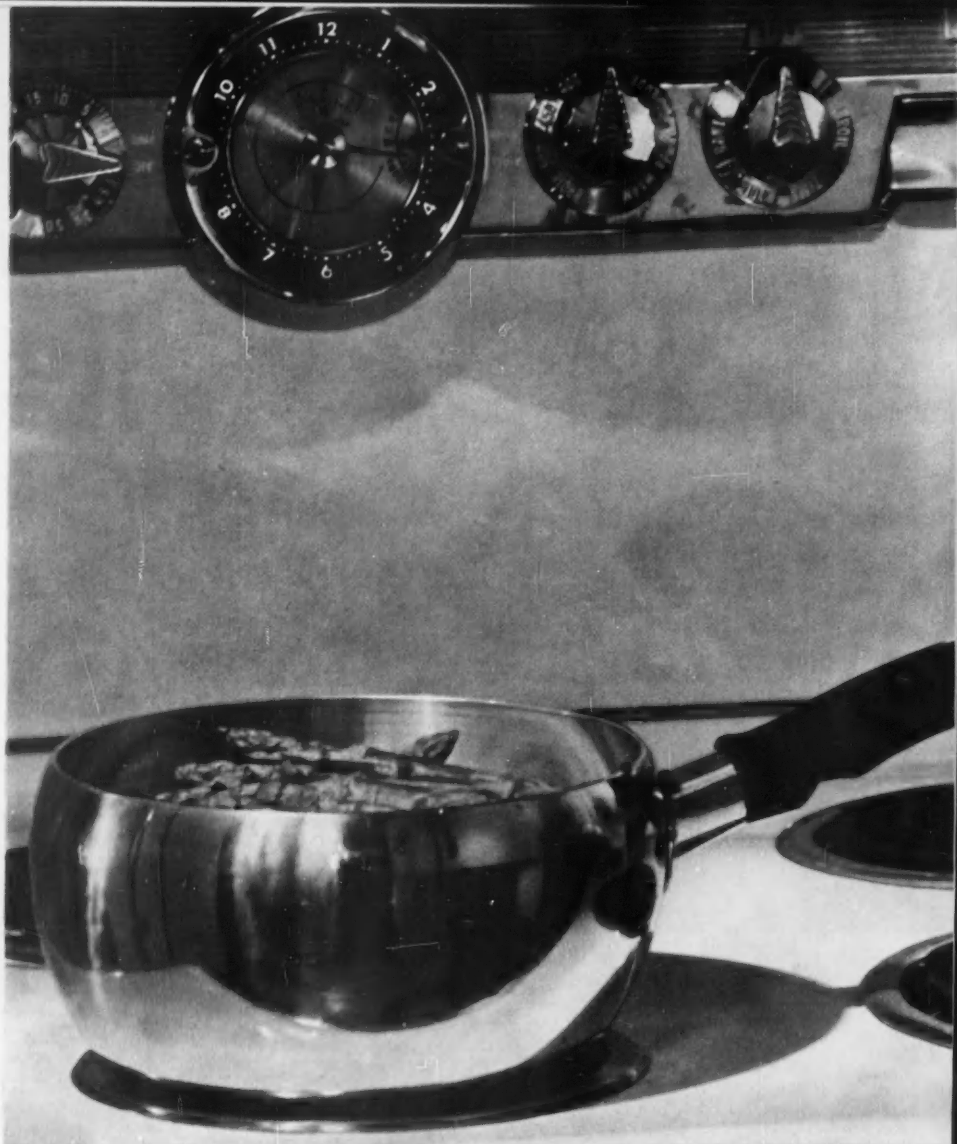
Dynamic braking uses the motors to retard the locomotive and train on hills and to slow the train for stops. This not only saves wear on shoes and other brake gear but also gives precise and easy control. The locomotive, designed with the crew's comfort in mind, has an amply heated, quiet cab.

To prove their new locomotive, the builders looked around for a neighboring railroad that carried heavy freight traffic over challenging terrain. The Erie met all these requirements and was convenient to headquarters as well. They agreed to supply crews, fuel, and the usual maintenance. A G-E observer would ride the locomotive to gather special data on each run. Numbered the 750, the locomotive joined the pool at Marion, Ohio, where it took its turn with the others on the regular run to and from Hornell, NY. On this 400-mile trip, the 750 handles any of the road freights that come along including Erie's hot-shots between Chicago and New York, which operate at schedule speeds usually attained only by passenger trains.

Mileage accumulates rapidly in pool service. In its first 18 months, the 750 covered more than 186,000 miles, or about 2400 miles per week.

During the first year of operation, six observers were needed to gather the figures, facts, and ideas that the designers will use in creating future locomotives.

The observers—young engineering graduates beginning their careers in transportation engineering—will later specialize in design, development, or sales. Their tour on the 750 was part of their training; apparently a few hectic moments in a freezing, swaying engine room taking emergency action provide a powerful incentive to eliminate sources of locomotive troubles during the design stages.



Automatic cooking unit boils, fries, and warms food without attention, making everyday utensils automatic. The modern homemaker has better results for less time and effort with . . .

Controlled-Temperature Cooking—Progress

By S. C. JORDAN

The electric appliance industry strives toward one objective: to lighten the modern homemaker's burden by producing better results with less time and effort on her part.

Visitors to this country may marvel at the myriad appliances that simplify household tasks. But the American woman takes them for granted, willingly accepting even more automation in her kitchen. Most of the chores—laundering, ironing, dishwashing, disposing of food waste, and cooking—taken over partially or completely by appliances make her life pleasanter and more leisurely.

Until recently, surface cooking hadn't changed much despite the convenience of electric ranges with their push-button controls, automatic timers, and other features (photo).

Grandma's Oven

Not too many years ago when the first practical oven thermostats were introduced, many women exclaimed, "Grandmother was a wonderful cook and she used a wood stove. So who needs an oven thermostat? Automatic, fiddlesticks!"

But Grandmother's delicious pies, cakes, and roasts were the result of many hours over a hot stove. And she had to find the right temperatures by trial and error. Many failures taught her that foods require numerous and varied cooking techniques.

Your wife, the modern homemaker, shouldn't have to spend years learning how to handle oven-cooked foods. Today an oven thermostat makes an expert cook out of any housewife willing to follow directions. Automatically, the thermostat brings the oven to a set temperature and then cycles the heating element on and off to maintain it.

s in the Kitchen

Meanwhile, your wife is free to make other contributions in the home, at business, or in civic affairs.

Surface Cooking

A logical outgrowth of the thermostat-controlled oven is automatic, or controlled-temperature, surface cooking.

If you're not particularly familiar with culinary art, surface cooking employs two main processes: frying and boiling. Adapting a controlled-temperature system to these fairly simple processes is tricky. A look at each separately will explain the control of surface cooking.

Frying . . .

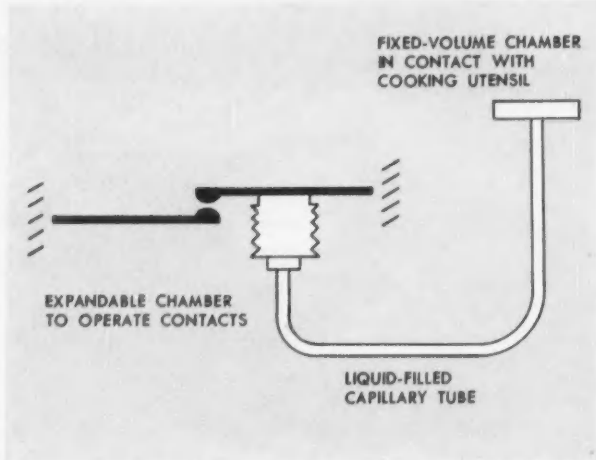
When your wife fries food on an electric range, she places the food in a utensil and turns on the power to the surface unit. This unit, incidentally, supplies a number of power levels depending on the switch position used. Surface units are operated by heat switches ranging from five and seven heats to an infinite number. The latter gives a continuous range of wattages varying from zero to maximum.

Each of these switch positions brings the utensil to a temperature where its heat absorption and radiation losses just equal the heat input. Temperatures differ with utensils. But a good cook can get excellent results using only five power levels on an electric range.

Each food has an optimum frying temperature—but finding it may be complicated. For you can't fry one-inch chops in different size skillets over the same heat setting and expect equal results, because heat distribution and radiation losses vary with skillet size.

To compensate for this differential, your wife needs a general set of directions. She determines the proper dial setting by carefully observing the food as it fries. This consumes both her time and attention—an obvious drawback.

The alternative: an automatic surface unit, or controlled heat, that frees your busy wife from one more kitchen chore. She has only to set the proper temperature, and frying becomes an extremely simple operation. What's more, the



TEMPERATURE-SENSITIVE DEVICE (ARROW) OPERATES ON THE PRINCIPLE THAT LIQUID VOLUME VARIES WITH TEMPERATURE CHANGE.

proper temperature automatically maintained produces the best results.

. . . and Boiling

Although simpler than frying, boiling presents a more difficult control problem to the engineer.

Boiling requires putting food in a pot of water and placing it on the electric surface unit. Immediately, your chief cook will switch the unit to high heat to bring the water to a boil. At the boiling point, she reduces the heat to a lower setting, depending on how vigorous a boil the food requires.

Here the wife skilled in the art of cooking uses many and varied techniques. Some women, for example, use large amounts of water while others do not. Some cover the pot; others don't. But no matter which technique your wife uses she can get excellent results by manually selecting switch positions.

Controlled temperature does little or nothing to improve the quality of boiling food. Water begins to boil at 212 F; any additional heat only increases the rate of boiling and doesn't affect the maximum temperature.

Controlled temperature, however, can do two things. First, it can relieve your wife of watching for the pot to boil. When it does boil, the unit automatically switches to a lower heat. Second, the automatic surface unit helps prevent the pot from boiling over or boiling dry and can save the food from burning if accidentally left on the unit too long after the food is cooked.

How It's Done

A temperature-sensitive device located in the center of the surface unit functions as the temperature control on the electric range (photo). A hydraulic thermostat, this control is spring-loaded against the pressure of the pan's bottom. It operates on the principle of the changing volume a liquid undergoes with temperature change (illustration). Liquid in the fixed-volume chamber contacting the utensil's bottom expands through a capillary tube into an expandable chamber that opens a pair of electric contacts. When the liquid contracts, the contacts close, applying heat to the surface unit.

Such a system gives dependable and economical control of temperature. Relatively inexpensive, its parts perform well and have good service life.

While the system readily controls frying temperature, it has no provision for controlling boiling rates—slow or fast-rolling—which depend on the amount of heat consumed.

An auxiliary device controls boiling rates. Like the hydraulic thermostat, it too is regulated by the dial setting located on the backsplash.

If your wife wants to cook peas at a low boil, she simply sets the pot on the surface unit and turns the control knob to Low Boil. The unit rapidly heats up, bringing the food to its boiling temperature. At that point the thermostat cuts out, and the auxiliary device takes over. It begins to cycle the surface unit on and off, maintaining the average boiling rate set on the dial. If your wife later wants a higher boiling rate, she turns the dial to a higher boil position. Although the surface unit continues cycling on and off, it now stays on for a longer time interval.

As long as some liquid remains in the pot, the peas continue to cook at the average boiling rate set on the dial. Now if the pot boiled dry while your wife talked on the phone, its temperature would sharply rise. When it reaches a certain temperature—say, 230 F—the hydraulic thermostat's detector senses this and immediately shuts off the power supply to the surface unit. Thus foods are prevented from burning even if the pot boils dry.

Keeping the Pace

Today's electric cooking with controlled temperature—a long step from grandmother's wood-fired oven—represents engineers' latest advance in their efforts to lighten household chores.

With continual perfection, controlled-temperature cooking will emerge as a milestone of modern living. Along with other developments in electric cookery, it will give your wife faster, cleaner, more economic, and better cooking results.

Yet this is but an indication of things to come. Last year, Americans used more electricity in their homes than ever before—120.5 billion kilowatt-hours, or one fifth of the nation's total production. In 8 to 10 years, this figure may double.

If progress in appliances keeps abreast of this prodigious pace—and it seems likely to—even the sophisticated American housewife may be impressed. Ω

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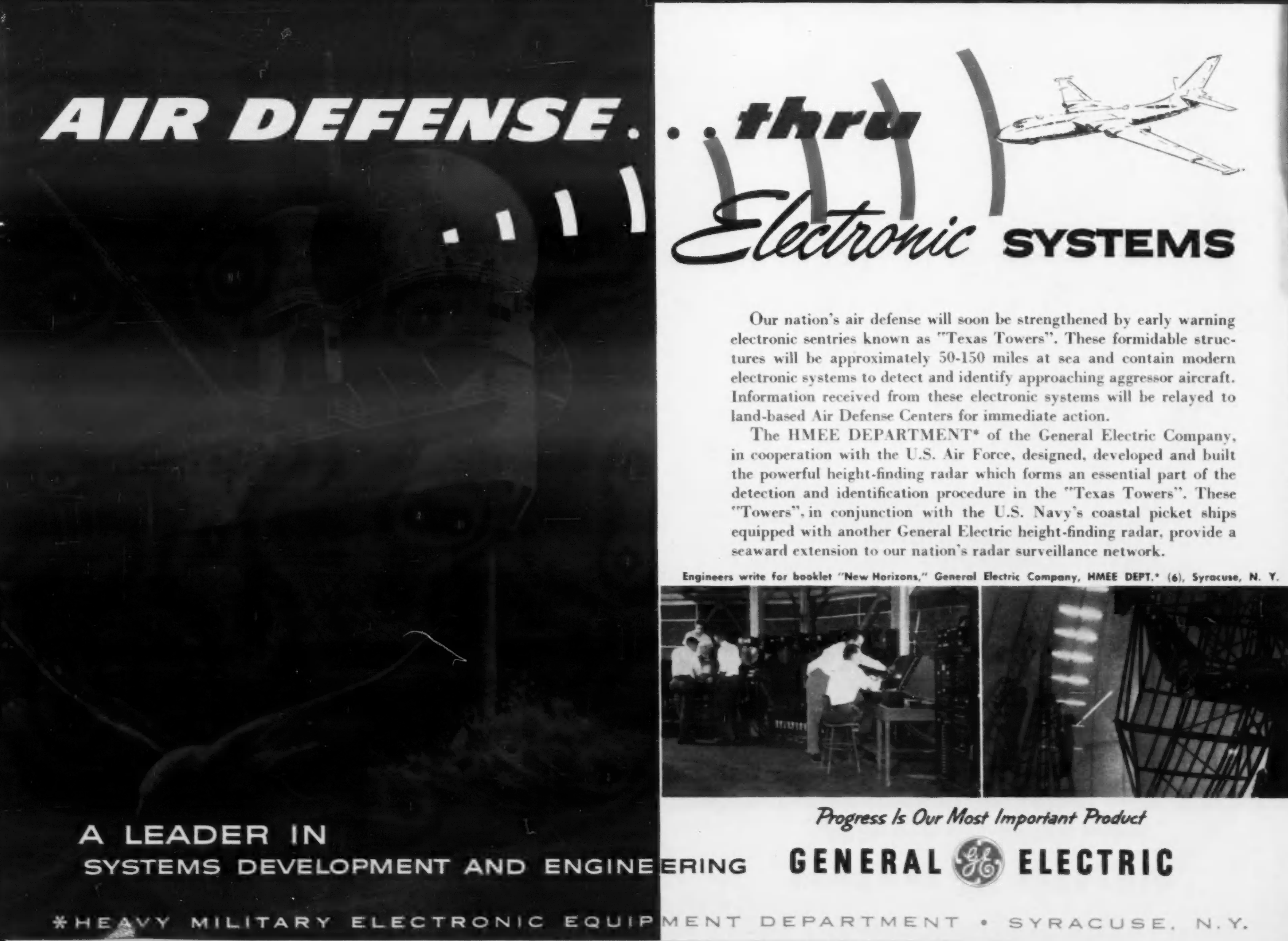
Mr. Jordan joined GE in the Engineering Section, Fan Department in 1947. Later he transferred to the Range and Water Heater Department, Appliance Park, Louisville, Ky., where he is now Project Leader of Components and Controls.


AIR DEFENSE . . . thru
Electronic SYSTEMS
Our nation's air defense will soon be strengthened by early warning electronic sentries known as "Texas Towers". These formidable structures will be approximately 50-150 miles at sea and contain modern electronic systems to detect and identify approaching aggressor aircraft. Information received from these electronic systems will be relayed to land-based Air Defense Centers for immediate action.
The HMEE DEPARTMENT* of the General Electric Company, in cooperation with the U.S. Air Force, designed, developed and built the powerful height-finding radar which forms an essential part of the detection and identification procedure in the "Texas Towers". These "Towers", in conjunction with the U.S. Navy's coastal picket ships equipped with another General Electric height-finding radar, provide a seaward extension to our nation's radar surveillance network.
Engineers write for booklet "New Horizons," General Electric Company, HMEE DEPT.* (6), Syracuse, N. Y.
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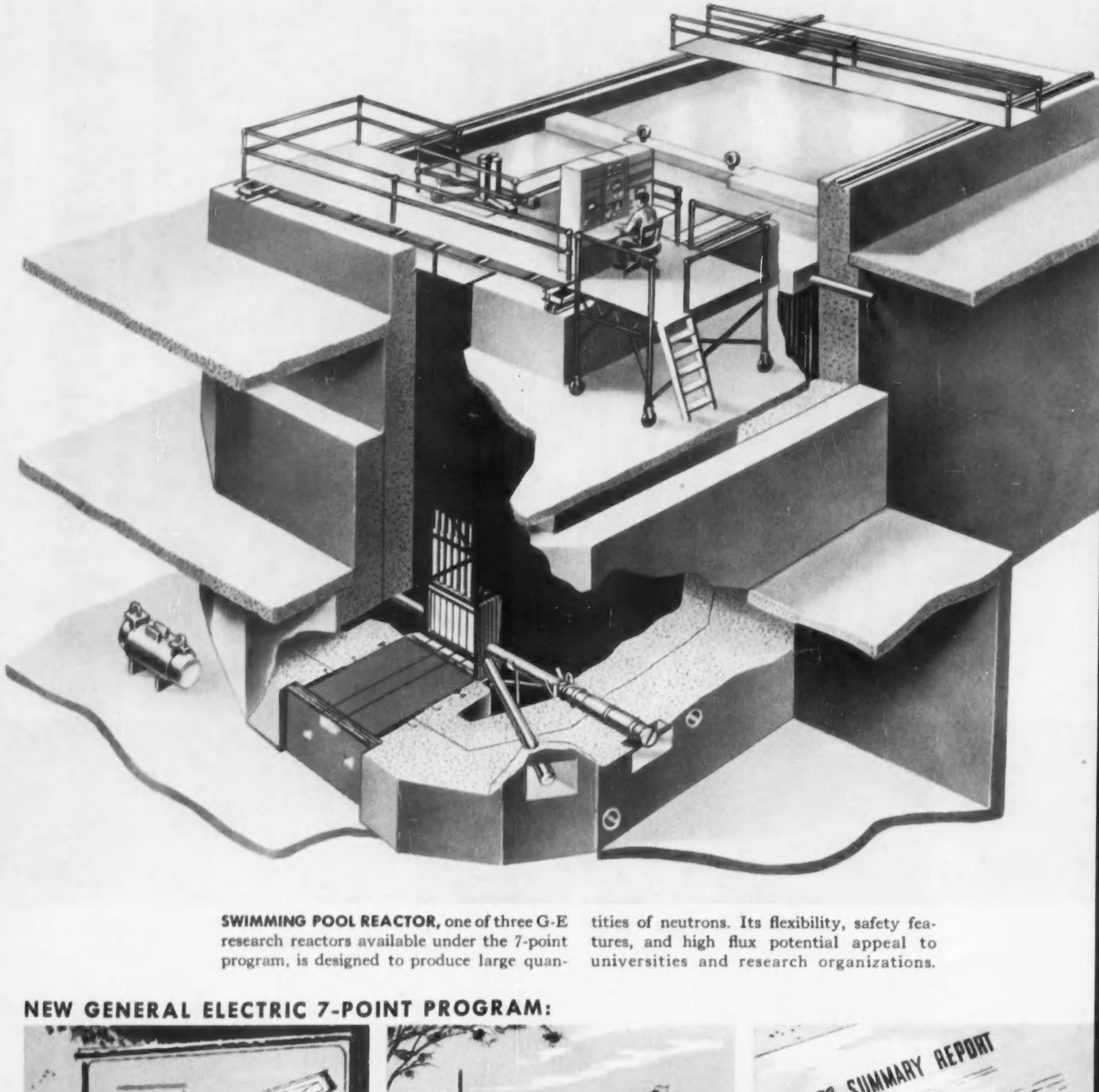
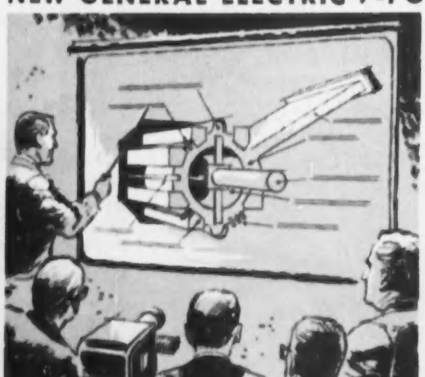


SWIMMING POOL REACTOR, one of three G-E research reactors available under the 7-point program, is designed to produce large quantities of neutrons. Its flexibility, safety features, and high flux potential appeal to universities and research organizations.

NEW GENERAL ELECTRIC 7-POINT PROGRAM:



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2 BUILDING STUDY also includes complete co-ordination of all plans for the many facilities required in the reactor and laboratory buildings.

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How General Electric can help you enter advanced nuclear research fields

New G-E 7-point program simplifies procedure for obtaining a nuclear research reactor

There is more work involved in obtaining a nuclear reactor for advanced research than simply ordering one. Specific research requirements must be determined beforehand, an appropriate design selected, and necessary AEC construction permits and licenses obtained. Other essential steps are covered in the program outlined below.

NEW GENERAL ELECTRIC 7-POINT PROGRAM is a plan designed to materially aid you in putting a research reactor to work. Through this program you can obtain any one of three General Electric research reactors: The Swimming Pool Reactor, Heavy Water Research Reactor, or the Nuclear Test Reactor.

FOR MORE INFORMATION on these three research reactors and the new General Electric 7-point program, write for bulletin GEA-6326, General Electric Company, Section 191-1, Schenectady 5, N. Y.; or contact your nearest G-E Apparatus Sales Office. Outside the U.S. and Canada, write to: International General Electric Co., 570 Lexington Ave., New York, N. Y.

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4 MANUFACTURE OF REACTOR is accurately co-ordinated with other construction plans, thereby assuring centralized project scheduling.

5 REACTOR INSTALLATION is supervised at the site by the men who have followed the design and manufacture of the complete system.

6-7 START-UP AND SERVICE under supervision of experienced personnel is added assurance that proper operation of your system will be maintained.

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4 MANUFACTURE OF REACTOR is accurately co-ordinated with other construction plans, thereby assuring centralized project scheduling.

5 REACTOR INSTALLATION is supervised at the site by the men who have followed the design and manufacture of the complete system.

6-7 START-UP AND SERVICE under supervision of experienced personnel is added assurance that proper operation of your system will be maintained.