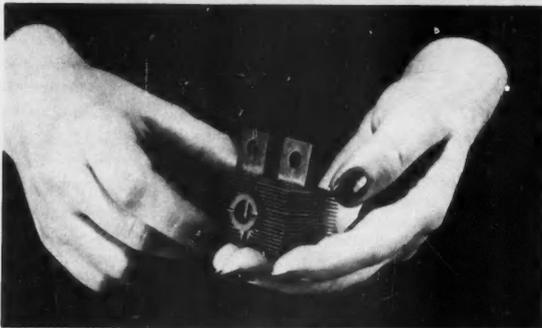
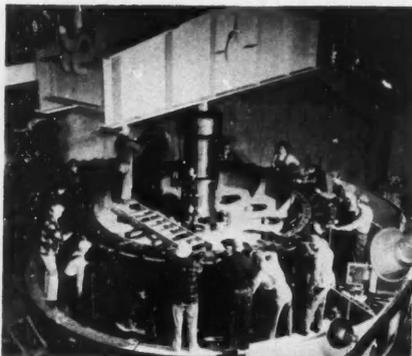


**GENERAL
ELECTRIC**

Review



RESEARCH AND ENGINEERING PROGRESS • 1951

JANUARY 1952



Chemical Progress

News of developments from General Electric's Chemical Division that can be important to your business.



SAVE SCARCE METALS WITH NEW G-E COATING INTERMEDIATE

Here's a new and versatile product of General Electric's program of chemical research. It's R-108, a coating intermediate that provides exceptional resistance properties to industrial finishes.

Finishes formulated with R-108 are highly resistant to chemical corrosives. Their use extends the life of steel shipping containers like tank cars and drums. Ordinary steel chemical processing and manufacturing equipment, coated with finishes containing R-108, can often be substituted for expensive and hard-to-get alloys.

Coatings made with R-108 are mar-resistant, adhere well to metals, glass, wood and plastics, and fit in easily with standard techniques for applying and baking.

This picture shows how a corrosive poured on a metal section coated with R-108 (to right) doesn't affect the surface! Untreated section (to left) is badly scarred. Tests also show that R-108 imparts unusual toughness, adhesion and heat resistance to metal finishes.

You can obtain a complete technical report on R-108 by writing to: Chemical Division, General Electric Company, Pittsfield 14, Mass.



G-E PLASTICS FOR DEFENSE

General Electric chemical products are already being used in many important defense applications. Among the numerous products and services offered are new, expanded molding facilities which enable G.E. to mass-produce low-cost plastics parts quickly and efficiently. Injection machines range in size from 1 1/2 to 208 ounces; compression and transfer equipment, from 3 to 36 inches. G-E chemical plants are located at Pittsfield, Mass.; Schenectady, N. Y.; Waterford, N. Y.; Coshocton, Ohio; Decatur, Ill.; Taunton, Mass.; and Anaheim, Cal.

PLASTICS COMPOUNDS • SILICONES • INSULATING MATERIALS • GLYPTAL® ALKYD RESINS • PLASTICS LAMINATING, MOLDING, AND EXTRUDING

You can put your confidence in

GENERAL  ELECTRIC

**GENERAL
ELECTRIC**

REVIEW

EVERETT S. LEE • EDITOR

PAUL R. HEINMILLER • MANAGING EDITOR

RESEARCH AND ENGINEERING PROGRESS • 1951

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THE COVER is but a cross section of the significant research and engineering advances of 1951 . . . For example, a new protective coating—corrosion resistant and highly flexible—can be substituted for hard-to-get alloys on cans, drums, and containers . . . To demonstrate how good lighting contributes to industrial efficiency and morale, a Lighting Mobilization Center was established at Nela Park . . . In the field of electronics, germanium rectifiers are assuming more and more importance in equipment for the military and industry . . . And in 1951, two of the world's largest motors went into operation at the Grand Coulee Dam. Installing the 170-ton rotors required precision guidance.

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.

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The GENERAL ELECTRIC REVIEW

WITH this issue, the GENERAL ELECTRIC REVIEW brings New Year's Greetings to its friends. And with this issue, it also undertakes new and enlarged responsibilities.

In 1952 the REVIEW enters its fiftieth year. The years since 1903 have seen the most outstanding advances in the electrical industry for the benefit of mankind. And as the engineers and scientists of General Electric have made their contributions, the REVIEW has carried their records of accomplishment as a helpful service to others.

I well remember when I was a junior in Electrical Engineering at the University of Illinois in 1911; the GENERAL ELECTRIC REVIEW was to us a most up-to-date authority in technical matters. We frequently carried the issues along with our textbooks and, when we left the University, they served as a trunk lining of more than casual value.

Those were relatively early days in the electrical industry, and we came to know the pioneers of General Electric in the REVIEW. Among these were Elihu Thomson, who was the first great American scientist to devote his talents to industry, and whose inventions extended into practically every electrical field. There was his righthand man, E. W. Rice, Jr., a brilliant engineer and a sound judge of men, who became president of General Electric. There were many others. There was Dr. Charles P. Steinmetz, a great engineering leader and a master of mathematical analysis, who could visualize the physical phenomenon and express it in terms of the mathematical equation to bring into being a practical result. In the same paths he taught and inspired the engineer associated with him. And there were Dr. Ernst J. Berg, mathematician, engineer, and beloved teacher of young men; William L. R. Emmet, engineer of turbine fame with great initiative and courage; Albert G. Davis, brilliant patent lawyer, who by his technical knowledge and foresight acted as a powerful stimulus to invention and engineering development; William B. Potter, resourceful leader in electric railway development; Edward W. Hewlett, ingenious and inventive in the field of switchgear; William J. Foster, a pioneer in the design of electric generators and motors; Lewis T. Robinson, authority on measuring instruments; and that outstanding group of scientists

headed by Dr. Willis R. Whitney, first director of the General Electric Research Laboratory, together with his eminent associates Dr. William D. Coolidge, Dr. Irving Langmuir, Dr. Albert Hull, Dr. Saul Dushman, and Dr. Laurence Hawkins.

All of these men wrote for the REVIEW. Their writings have been an inspiration to others. And through the years as younger engineers and scientists have made their contributions, they too have written for the REVIEW, thus sustaining its reputation as a professionally authoritative magazine.

This is the tradition, and the heritage, which the new REVIEW seeks to extend. In the past, the circulation has been by subscription, reaching an important but comparatively small group of readers. Beginning now with this January 1952 issue, the GENERAL ELECTRIC REVIEW will be a bimonthly and will be sent without subscription cost to a greatly extended list of interested friends of General Electric. Giving it wider distribution, we believe, will expand its usefulness. We say hello to our friends of the past and send this initial greeting to many new friends who for the first time will be receiving the REVIEW.

It is our aim that the REVIEW shall continue to maintain its reputation as a professionally authoritative magazine. The articles will be written by engineers and scientists of General Electric for engineers, scientists, and engineering students of the world. The REVIEW will thus make available useful information and ideas concerning research, products and engineering developments, designs, applications, methods, and techniques for the advancement of electricity into every available avenue for the benefit of mankind.

This January 1952 issue brings a picture of the research and engineering progress made during 1951 by the engineers and scientists of General Electric. Thus is continued the recording of research, engineering, and manufacturing achievements published for many years by the REVIEW. And although it represents the electrical, mechanical, and chemical developments of but one company, it nevertheless indicates trends in the growth of the electrical industry as a whole.

As we thus enter the New Year, we trust that the message of the REVIEW will continue to be one of helpfulness.



EDITOR

HIGHLIGHTS OF THE YEAR

The keynote of research and engineering in General Electric in 1951 was mobilization for defense. That story cannot now be written; it must be reserved for later years.

But entwined with defense is the ever-present basic economy which must go on. And in General Electric it has gone on. For wherever there are scientists at work new knowledge comes forth, and wherever there are engineers at work new products come into being and old products are improved. So it has been in 1951.

The major emphasis in the year has been to effect every possible saving in materials and construction and to substitute less critical materials for critical. This is engineering at its best. And the examples of the accomplishments recorded include practically every line; the emphasis has been universally applied.

Redesign Helps Save Materials

In large generators, core loss has been reduced by almost one-third without redesign, while size and weight have been proportionately reduced with redesign, by using grain-oriented steel, a product of much intensive research from previous years. Redesign of 23,529-kva hydrogen-cooled and 15,625-kva air-cooled generators has produced lighter and smaller machines. And it has been demonstrated that the more extensive application and use of automatic generator-voltage regulators results in economies both in generator construction and in system operation.

In three-phase distribution transformers, through design application, weight reduction of 20 to 35 percent has been accomplished; by using Class B insulation, sealed dry-type transformers have introduced economies in operation, and air-cooled specialty transformers have been reduced approximately 25 percent in size and weight, with consequent saving of copper.

Medium-size turbine-driven generators for ships' service were redesigned to give weight reduction of 25 to 39 percent including coolers, accomplished

by applying axial ventilation for the first time, and by fully utilizing the allowable Class B insulation temperature rise.

Use of Critical Materials Reduced

Substitutes for critical materials involving a major engineering effort to save copper, nickel, aluminum, and cobalt were particularly pertinent in appliances. Plastics and plastics-coated steel replaced brass; fiber-glass-reinforced plastics replaced aluminum; cast iron replaced die-castings; in one valve nylon replaced brass. The magnetic latch for refrigerator doors was discontinued to conserve cobalt in the alnico magnets. By reducing the diameter of the heating unit in the G-E hand iron, an annual saving of 200,000 pounds of aluminum was accomplished, together with a saving of 46,000 pounds of magnesium oxide.

In all of this work the design requirement was that substitutions must not impair quality or performance; some sacrifice of appearance, increased weight, or increased costs were accepted. This was a further challenge to engineering ingenuity which has been met.

The chemist and the metallurgist are prominent in providing substitute materials. Protective coatings to give a corrosion-resistant surface on steel thus provide substitutes for many applications of expensive and hard-to-get alloys. Gears, bearings, retainer rings, and sleeves are now being molded from nylon.

Hard-surfacing of ferrous alloys with cemented tungsten carbide was developed to be almost as good as sintered tungsten carbide and to be several times better than hardened steel or chilled cast iron, while the drilling of cast iron with carbide-tipped tools continues to speed production processes for defense.

In switchgear a serviceable silver contact surface for aluminum bus bars was developed to be equal to that of copper with silver contacts; and for turbines critical alloying elements were saved by the further development of several low-alloy-ferrite steels. Thus do

the chemist and the metallurgist serve, and without their service there would be little opportunity for saving through substitutions.

Of like importance to the saving of materials is the saving of time. Here there are also impressive accomplishments. On one design of aircraft generator, inspection or replacement can be accomplished in ten minutes with a newly developed quick-attach-detach-mounting device. Today a new type of sealed-beam lamp aids refueling of bombers in mid-air, saving precious time. Thus does the engineer bring untold advantages through the advances he provides.

Major Advances Are Impressive

Everyone is interested in what is new; the list of "firsts" is always most impressive, and the list for the year 1951 is no exception. The engineers are always opening new doors and, if it were not for the engineer, the new doors would not be opened.

As with the "firsts," there is always interest in the "largest," or the "highest" or the "most advanced," and for 1951 the list of these is equally impressive. Greater output, more tonnage, higher efficiencies are some of the keys to our industrial productivity; the bases for these are superior engineering design and application to larger and larger units.

In addition to the engineering progress resulting in the "firsts" and the "largest," there are a multitude of accomplishments of most outstanding importance extending throughout the entire design spectrum of the equipment for the electrical industry. To list these would duplicate their description in the succeeding pages of this REVIEW, but we cite them here as evidence of the superior and constantly improved performance of new products in reverending succession as a result of the firm conviction by the engineer that there is always a better way.

The Challenge of New Conditions

New conditions are constantly arising to give birth to new attainments. The



Research requires the contributions of many groups before its results may achieve practical utilization, but it is the scientist himself who produces the vital foundation upon which the whole structure rests—the new fact of nature—Dr. C. G. Suits, Vice President and Director of Research

year 1951 was no exception. Increased ore tonnage from the Lake Superior region and development of new ore fields in South America and Labrador accelerated construction of ore unloaders at Great Lakes and Eastern seaboard ports. And into these went d-c pumpless ignitron rectifiers to serve the highly fluctuating loads, 17-ton man-trolley-type ore unloaders, 40-ton electric pusher locomotives, and amplidyne-controlled adjustable-voltage drive, all for increased tonnage handling.

Another example of engineering for new conditions is found in the use of gas turbines at the booster stations in the increasing natural gas transmission through pipelines from the Southwest to the industrial areas. Because electric power is not always available at the booster-station location, the idea of using gas turbines is attractive; additionally, the gas turbines require no water and, because they draw their fuel from out of the pipeline, they are completely self-contained units. Here again a new condition is met with a new engineering development.

Throughout production, the engineer

must maintain quality. New measuring instruments are ever being produced for better control of product. Corona-detecting equipment for testing full-reel lengths of cable was developed, and in the year every foot of 15-kv cable manufactured was tested for corona level in addition to the standard industry tests. The effective control of quality by the engineer is the guardian of the G-E monogram.

Development Expanded

Prominent in the province of the engineer is the ever-enlarging horizon of development, bringing products into being for the first time. Color television had its development upsurge in 1951; also, the exploration of the ultrahigh-frequency spectrum for television channels opened up an entirely new approach to television transmitter and antenna design. And many new electronic tubes of special types and of quality improvement were developed to meet the exacting requirements imposed by military necessity.

The heat-pump development program was advanced through the recording of

millions of items of operating data automatically on microfilm at 15 test installations in scattered areas to provide an invaluable basis for improving the heat pump and for developing application techniques.

Lighting was advanced through the new Lighting Mobilization Center at Nela Park where were assembled at one focal point all the demonstrations of seeing and lighting essential to nationwide industrial mobilization activities. The new Lighting Measurements Laboratory is producing pretested data that make it possible to predetermine illumination from any type of lighting system. And approximately 500 demonstration homes are increasing the public's light-conditioning consciousness. These are development services of the broadest scope.

New Knowledge from Research

There is always an eager interest in research—the work of the scientist from which continually comes new knowledge for the engineer to have and to use. Most of the progress recorded above has come from the research of many



It is the engineer's responsibility to take the new research discoveries as they come along and to put them to work for the benefit of man, and to find ways of doing it that industry and the people can afford—Harry A. Winne, Vice President—Engineering

previous years. And in 1951 research was still advancing. From the research work on the semiconducting element, germanium, a new rectifier with 1 kw of power rectified from an effective area of 1 square centimeter came into an advanced stage of development during the year, and following previous research, production of germanium diodes is in substantial progress. Thus the germanium crystal replaces the electronic tube for some uses; scientists and engineers have found that the electrons work in the solid as they do in a vacuum enclosure.

Continual research work with phosphors is in progress to bring better television tubes. Electroluminescence is nearing the stage where practical applications will be forthcoming. Electron beams in air permit the advance of radiation knowledge; and the use of high-velocity electrons in destroying microorganisms is being continued with a view to eventually applying this radiation process to the sterilization of food and drugs.

Continued research work in metals is bringing new ferrites for advances in

magnetic designs, and the application of the diffusion principle to metals testing has resulted in a new stress formula to decrease test time and greatly increase test output.

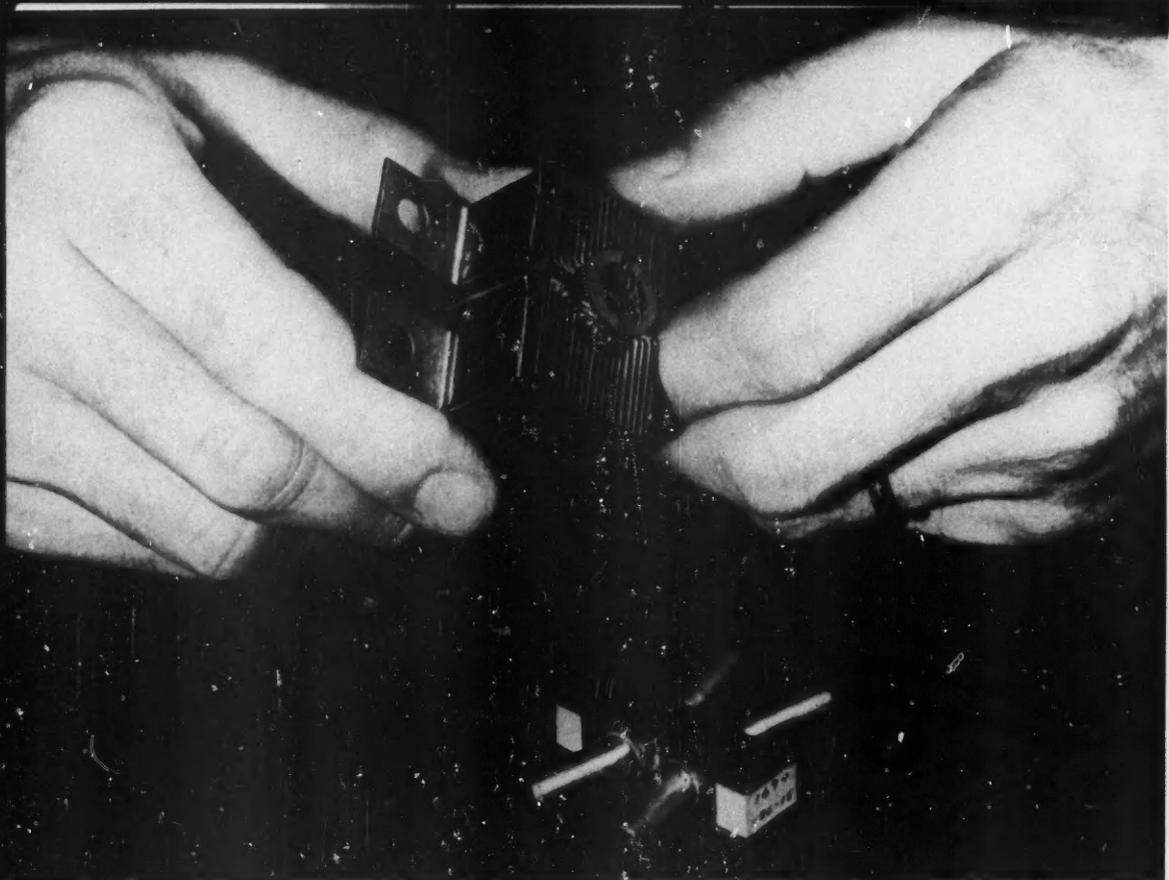
In nucleonics vast operations are in progress. Work on reactors for submarines and for aircraft was reported during the year. And the multitudinous factors present in this new field are being explored by the physicist and the chemist and the engineer for use as rapidly as research knowledge and economic factors will allow the developments to advance to the design stage.

Manpower Conserved

Engineering and scientific manpower has been the concern of the year. Everywhere there is a shortage, all of which makes it increasingly clear that the educational process must be continued in industry. In General Electric the responsibility for continued education after college has been recognized for many years. Young engineers and scientists joining General Electric are therefore, given an opportunity for

continuing their classroom education, in addition to a wide experience program. The education process is thus rounded out by an initial broad experience to follow the philosophy that one learns by doing. This process has during the recent years been expanded to include not only the electrical and mechanical engineers but also the physicists, chemists, chemical engineers, and metallurgists. This is conservation of engineering and scientific manpower. This assures that each man will have the foundation that will give him full opportunity to make his maximum contribution to the defense requirements and to the expanded development of the economy which supports the defense effort and which it is designed to protect.

Thus have the engineers and scientists contributed to the advances of research and engineering progress during 1951. And as their associates in manufacturing and marketing and all of the various services have worked together with them, the results have made available continued satisfactions to their fellowmen everywhere.



GERMANIUM RECTIFIERS—air-cooled type (top) and water-cooled type are the product of many years of research

Research

Research on the semiconducting element, germanium, has been in progress for many years. One important application of semiconductors is in current rectifiers, a number of which have been developed for production. The basic element in previous rectifiers has been either a point-to-plane junction or a small-area contact of the order of 1 square millimeter. The latest unit that is now in an advanced stage of development has an effective area of 1 square centimeter and can rectify 1 kw of power. Although the new rectifier has somewhat lower inverse-voltage rating than its predecessor (the G-10), it will pass several hundred amperes with only a 0.75-volt drop. An essential feature of

the manufacture of the new rectifier is the precise control of impurities that makes it possible to "tailor-make" a material to fit desired specifications.

Synchrotron Helps Fight Cancer

Another step in the fight against cancer was taken in 1951 with the installation of a 70 million-volt synchrotron at the University of California Medical School, the first of its type to be used exclusively for research in high-energy radiation for the treatment of cancer.

The 16-ton machine can be raised to 20 feet above floor level and rotated approximately 100 degrees about a horizontal axis, permitting the beam to be

directed at the patient from any angle.

Design features include a laminated-steel magnet, exciting coils, lead shielding, and heat exchanger—all located in a sound-absorbing enclosing case. Remote control gives protection to operating personnel.

Transparent Phosphor Screens

The internal scattering that takes place in powdered phosphor screens now used in television tubes has two bad effects: an over-all haze that limits the obtainable contrast, and loss of sharpness caused by light scattering within the phosphor screen. To counteract these effects, developmental screens were made by a process involving the



SEVENTY MILLION-VOLT synchrotron is one of the newest weapons that will contribute to the continuing fight against cancer

chemical reactions of vapors at the surface of the glass backing plate. Although the developmental screens produced thus far lack some of the brightness of conventional screens, they yield superior contrast and sharpness.

Electroluminescence

Phosphor research in the field of electroluminescence is nearing the stage where practical applications—such as self-luminous instrument dials—will be forthcoming. Electroluminescence is a phenomenon in which electrical energy is converted directly into light in the phosphor without the intermediate steps that are involved in fluorescent lamps and cathode-ray tubes. In this process the phosphor powder is supported in a dielectric medium between two plates of a capacitor, one of which is transparent.

The application of voltage to the capacitor plates excites phosphorescence; the brightness depends on the voltage and the frequency of the applied field.

Electron Beams in Air

Several methods for leading the electron beam out of the doughnut of the 30-mev synchrotron were tried during the year. Considerable success was achieved with an electrostatic method that permits using the electron beam itself for radiation experiments or of causing the beam to strike a tungsten target inside the doughnut, thereby generating an x-ray beam that can be used for radiation studies.

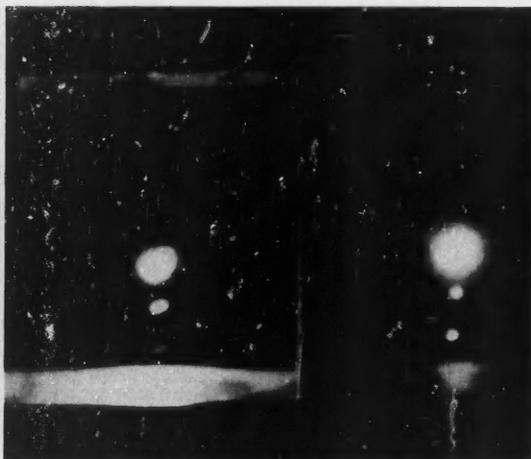
High-speed Sterilization

For the past two years work has been underway on the use of high-velocity electrons in destroying micro-organisms,

with a view to eventually applying the process to the sterilization of food and drugs. Using a one million-volt x-ray unit, material is shot with an ionization dose of one million equivalent roentgen units in seven seconds at a distance of 10 centimeters. A dose of this magnitude is lethal for most molds and bacteria; and, because the temperature rise is relatively small, the method has possibilities for the sterilization of temperature-sensitive materials, such as penicillin and blood plasma.

Voltage Tests on Silicone Rubber

High-voltage ionization tests on silicone rubber with sharp-edged electrodes under alternating-voltage stresses of 194-kv peak per centimeter, over a temperature range from room to 170 C, show that this material is extremely resistant to corona when compared to



TRANSPARENT PHOSPHOR coated on TV tube gives superior contrast and sharpness (left); conventional phosphor (right)

hydrocarbon insulation, such as natural and butyl rubber.

New Ferrites

Several new ferrites were investigated for magnetic-core materials for radio-frequency coils and transformers. They show higher permeabilities and lower power losses than previously reported. Indications are that by using

one of these ferrites a conventional i-f transformer of greatly reduced size and higher selectivity is possible. Engineers are now exploring the possibilities of using these materials for magnetic amplifiers and for replacing electronic tubes in high-speed computing machines.

Turbine-bucket Tests

To reduce testing time and cost of

turbine-bucket tests, a vibrator was developed that closely simulates the operating conditions of an actual turbine wheel. The procedure involves exciting a single turbine bucket at a resonance frequency by means of accurately timed impulses produced by interrupting a high-pressure high-temperature air blast. Tests show that the incidental damping produced by a certain amount of looseness in the bucket mounting plays a vital role in the endurance of the bucket in operation.

ELECTROLUMINESCENCE will find many important uses both in home and industry



Stress Formula

Metals under stress at high temperature are not nearly so strong as at ordinary temperature and, when stressed to the breaking point, rupture with very little warning stretch. Late in the year a mathematical relationship was discovered that relates strength with time and temperature. This relation is $P = T(C + \log t)$ where P is a constant for constant stress and a particular material, T is the absolute temperature in degrees Rankine, C is a material constant that has a value of about 20 for all materials, and t is the duration in hours of the stress. With the new equation it is possible to select materials for use in long-lived equipment on the basis of creep and rupture tests that require months instead of years. This work reduces the delay between the development and the application of new alloys, and greatly increases the output of testing facilities.



IRRADIATING FOOD with high-velocity electrons destroys most molds and bacteria. Temperature rise is relatively small

Bearing Research

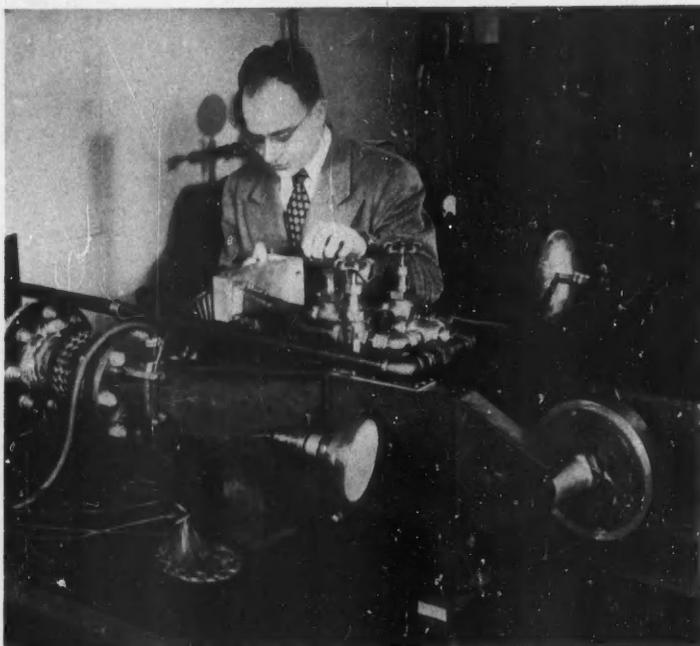
Oil flow, power consumption, temperature rise, and limiting speed in cylindrical bearings—such as those used in turbines, gears, motors, and generators—was carefully worked out on the basis of developmental data and a novel theoretical analysis. The calculated oil flow is balanced by graphical means with power loss through the use of the vis-

cosity-temperature characteristics of the lubricating oil. The results are useful in selecting the lubricating oil, bearing sizes, clearances, and other factors for use in many types of electrical apparatus.

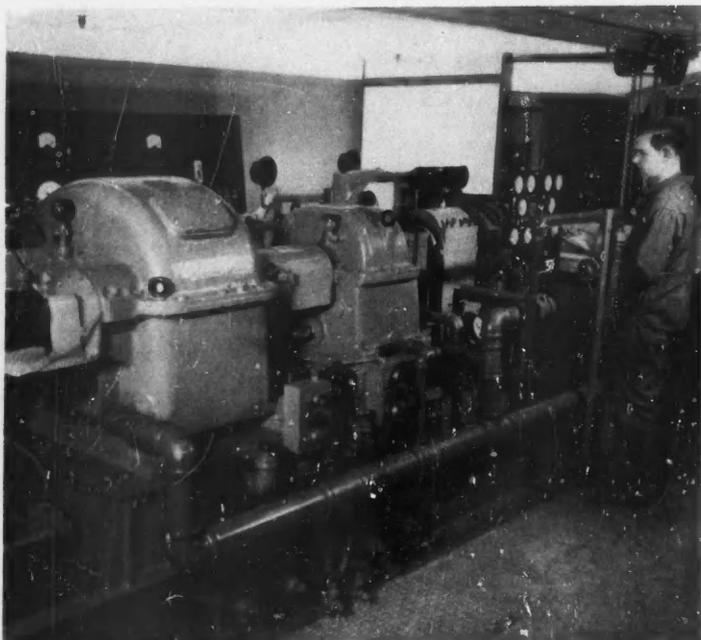
Nucleonics

Work on a submarine intermediate reactor (SIR) power plant made progress

in 1951. Other programs at the Knolls Atomic Power Laboratory (KAPL), a laboratory near Schenectady operated by the General Electric Company for the Atomic Energy Commission, include a continuation of assistance to the Hanford Works, Richland, Wash., and a new program of assistance to the E. I. duPont de Nemours & Company, Inc., in connection with the AEC Savannah River Plant.



TURBINE BUCKETS are tested by closely simulating operating conditions



BEARING RESEARCH—speeds to 30,000 rpm and loads to 65 tons are studied

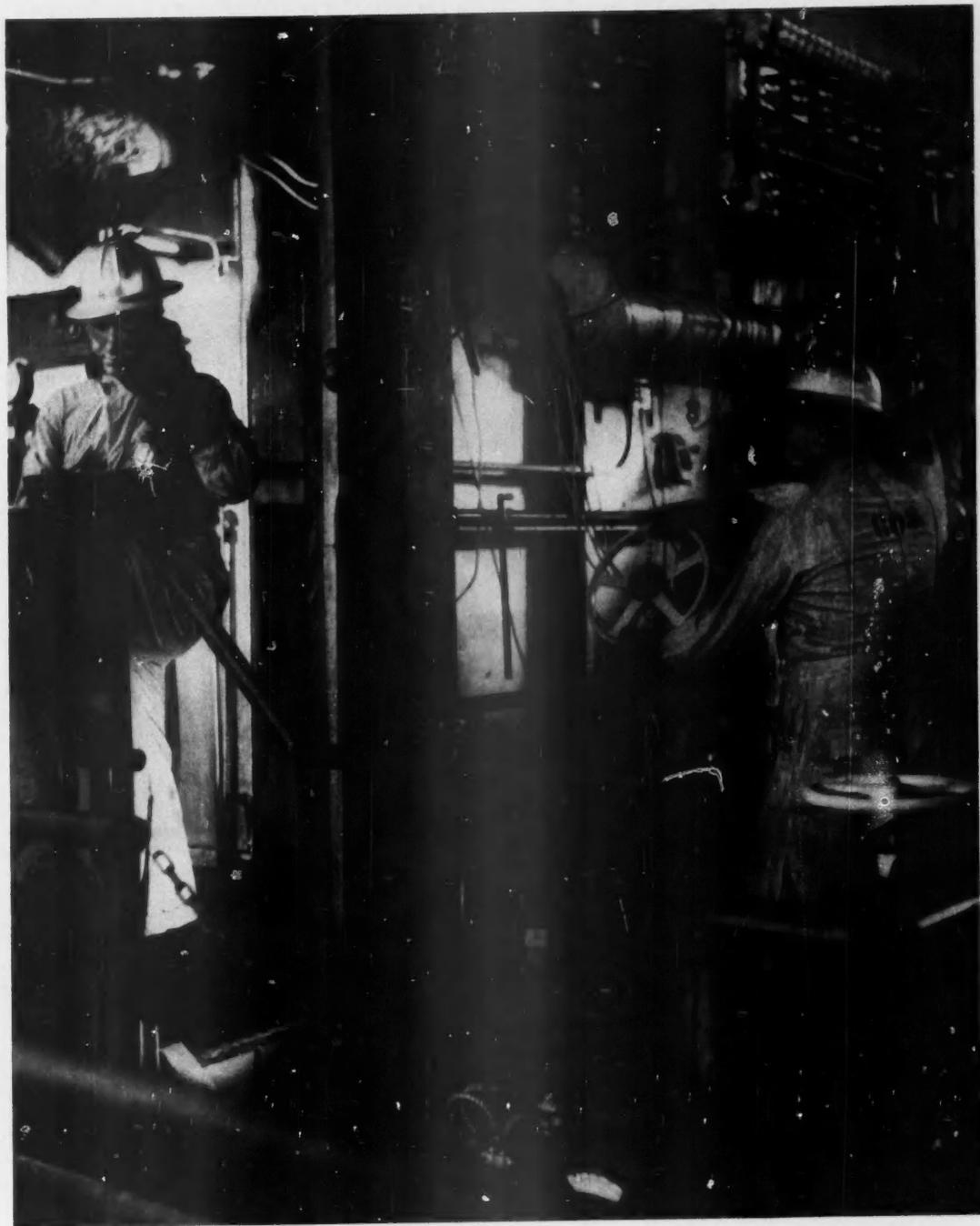
The preliminary pile assembly, in operation at KAPL since April 1948, was redesigned, housed in a new building, and continued to be a flexible developmental tool for obtaining accurate data about atomic nuclei—data that were important in reactor design both as regards the structural material and the nuclear fuel.

Extensive experience has confirmed that liquid sodium is a practical heat-transfer medium to remove heat from the SIR power reactor, transfer it to steam, and hence drive a turbine. Compared with water, it has the advantages of low pressure at high temperature and superior heat-transfer properties. An interesting development that utilizes the metallic properties of liquid sodium makes possible the pumping of sodium by direct application of electromagnetic forces. This so-called "electromagnetic pump" is similar in principle to an induction motor, the main difference being that the electromagnetic forces are exerted on the sodium in a duct rather than on a conventional rotor. A pump of this type is very good for use with radioactive fluid as it avoids possibility of even small leakage through seals and has no moving parts to require service.

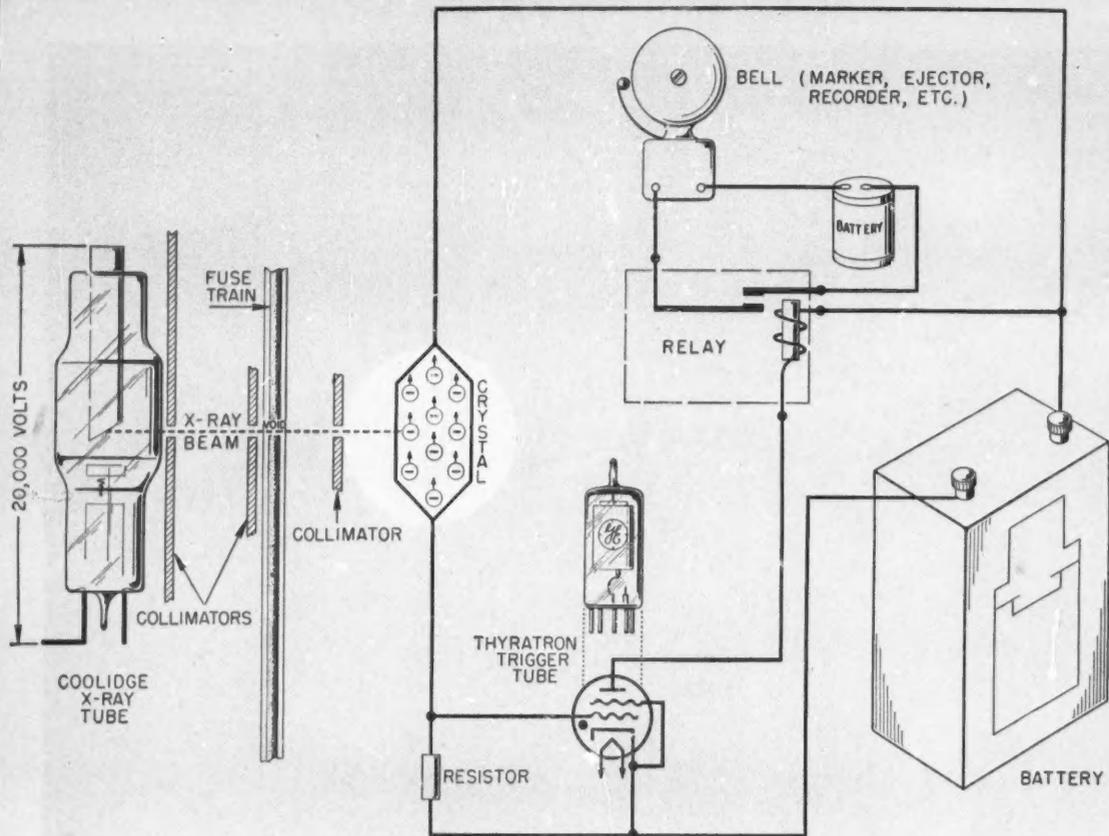
The program for planned expansion of plutonium production facilities at the Hanford Works was continued during 1951. Further studies were made during the year to increase plutonium output with existing facilities. A substantial improvement in plutonium output over 1950 was realized by the close of 1951. The continued effort to reduce costs resulted in a further reduction in the unit cost of plutonium by a substantial amount under the cost in 1950.

During the year a hand and foot counter was developed for radiation detection. The unit allows rapid semi-automatic monitoring for beta and gamma contamination of the hands and feet of workers at atomic-energy installations.

An area health monitor was developed to supplement the personnel film badges and pocket ion chambers now used to measure x-ray or gamma radiation in laboratories, atomic-energy plants, and other areas subject to radioactivity. It presents in one compact assembly an accurate instantaneous reading; a 30-day record integrated over 15-minute intervals; and a reading for any preset period.



LIQUID SODIUM heat-transfer problems—such as removing heat from a reactor—are studied on this test apparatus



HIGH-SPEED automatic x-ray inspection of blast-fuse powder train uses new cadmium-sulfide crystal as an amplifier

Testing and Measuring

A tiny cadmium sulfide (CdS) crystal that apparently amplifies one million times promises to be the heart of a new system for high-speed automatic x-ray inspection of industrial products.

These crystals, which can be "grown" in size from a fraction of a millimeter to several millimeters, act as an amplifier when excited by x-radiation. On an area-for-area basis, they are up to a million times more sensitive than conventional ionization chambers and a thousand times more sensitive than photoelectric cells.

Sensitive, stable, responsive, the

crystals do the work formerly handled by a complex system of electron tubes and amplifiers, while at the same time allowing the use of comparatively low-intensity x-rays.

A prototype of the new system is being used on a military production problem to measure the level of a corrosive liquid; other pilot-laboratory units have been built to inspect rubber heels, to determine the continuity of blast-fuse powder trains, and to indicate the product level in canned and packaged products. Inspection speeds in some cases are as high as 600 units per minute.

Analizers Now Interconnected

New interconnections and modernization during 1951 expanded the capacity and speed of operation of the Company's two a-c network analyzers. The units may be used either separately or combined to form a single analyzer having 24 generators and more than 700 circuit elements.

These improved analyzers have greatly increased the number of power-system studies that are now being made in Schenectady at a time when the utilities are particularly in need of such services.

A Reeves electronic differential analyzer was placed in service to extend the capacity of the analyzers in Schenectady for the numerous complex engineering studies that require immediate solution in the development of new equipment and systems.

Radiation Probe

A new portable radiation probe was developed in 1951 for use with most commercially available instrument counters. Operating as a scintillation-type detector, this device detects alpha, beta, and gamma radiations, as well as x-rays and thermal neutrons. When used with an extension cable between it and the scaler, the probe is well adapted for use in surveying particle-accelerator and nuclear-reactor installations and for contamination surveys of laboratories and apparatus.

Mass Spectrometer for Process Control

A new mass spectrometer has been developed which operates on the ion-resonance principle. Encouraging results have been obtained from tests made on gaseous mixtures, including hydrocarbons; and it is believed that this new-type mass spectrometer may soon be applied to the monitoring of hydrocarbon streams.

Corona "Sniffer"

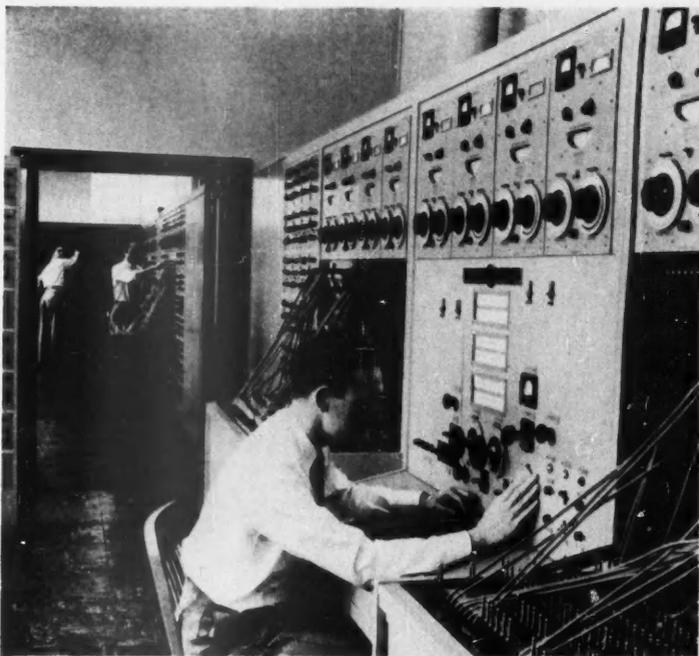
A corona "sniffer" was designed for use in the examination of large motors and generators. Capable of distinguishing corona on adjacent coils of a large machine, this device amplifies a signal from the sensing element and gives a visible signal on a cathode-ray oscilloscope.

Winding-insulation Tester

The latest in a series of winding-insulation testers was developed in 1951. This newest surge-voltage tester is similar to earlier testers, but was specially designed to test very low impedance loads, such as d-c traction-motor armatures. With a maximum surge voltage of 7500 volts, the tester can also be used to surge-test series field coils and a-c stator coils up to the size used in 10,000-kva turbine-generators.

Vibration Pickup

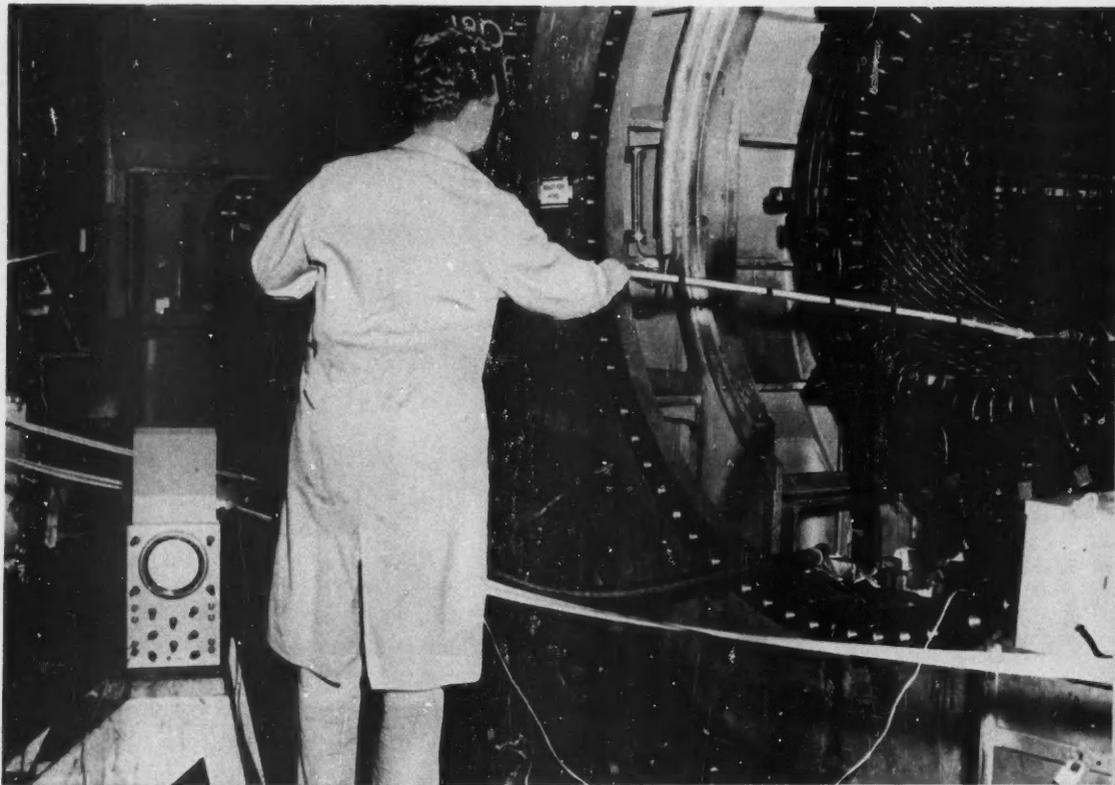
Development of a barium titanate vibration pickup in 1951 resulted from the need for a portable vibration accelerometer smaller than previous instru-



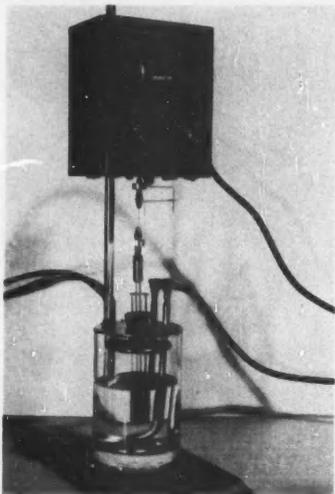
NETWORK ANALYZERS are now interconnected for solving power-system problems



RADIOACTIVE sources are readily checked with this portable radiation probe



"SNIFFER" checks coils of large generator for corona. Cathode-ray oscilloscope (left) shows amplified signal from sensing element (right) if corona is detected



GEL TIME of polymerizable substances is determined with this new meter

ments. This pickup, no larger than a $\frac{1}{4}$ -inch piece of pencil lead, has an output voltage 40 to 50 times that of earlier equipment.

Midget Tachometer Generator

Small and light in weight, a midget tachometer generator was built to fill the need for a speed-measuring device to be used in cramped quarters. Weighing less than a pound, the tachometer is adaptable for use with a remote indicator and is especially well suited for applications where thickness and weight are critical.

Gel-time Meter

The determination of gel time of polymerizable substances is made easy by using a new gel-time meter. This compact instrument can be read to one-tenth of a minute and is simple enough to be operated by persons unfamiliar with laboratory techniques.

Microwave-frequency Standard

During the year engineers built for the U. S. Army Signal Corps a microwave-frequency standard designed to increase the frequency of a 50- or 100-kilocycle standard to at least 24,000 megacycles per second. Incorporated with this new standard is a spectrum analyzer, by means of which the output frequency in the *S* or *X* bands can be observed visually.

Certified Watthour Meters

In 1951, mass-produced watthour meters were for the first time factory-certified for accuracy and performance. Seals attached to all Type I-50 watthour meters state that on the average the accuracies of the meters as shipped are within 0.1 percent of the reference kilowatt-hour, with the standard deviation of their accuracy distribution less than 0.15 percent at full load or 0.20

percent at light load. Performance is certified as being such that 99.9 percent of the meters are free from mechanical defects that might cause improper registration or operation. This results in cost reduction by eliminating initial inspection.

Exposure Meter

A new photographic exposure meter, the Mascot, small and light in weight incorporates a novel internal magnet of sintered alnico in a high-flux-efficiency magnetic circuit. The meter has nearly logarithmic response characteristics that make possible a simple dial calibrated directly in *f*-stops.

Resistance-thermometer Controllers

New resistance-thermometer controllers, sensitive enough to take advantage of resistance-temperature detectors in the -50 to $+150$ C range, were developed. A new approach to ratio design was made. The armature core is concentric with the pole faces giving a uniform air gap; but one pole face is cut in such a way that its effective height varies from point to point, thus producing the desired relationship between flux values and angular deflection.

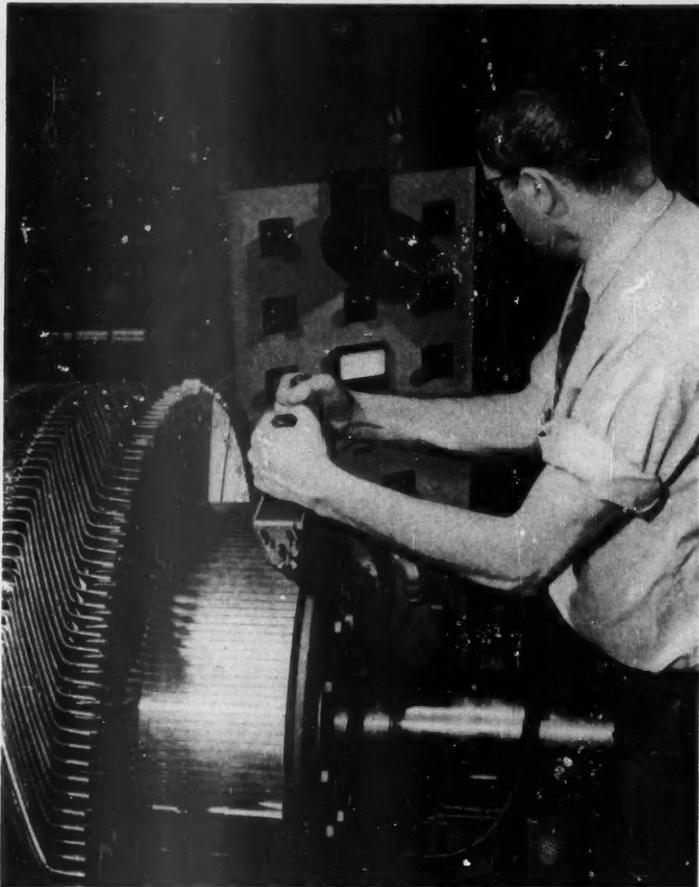
The instruments, which are supplied with either one- or two-position On-Off controllers, are sturdy enough to withstand the shocks and vibrations of industrial service yet are sufficiently sensitive to permit scale spans as small as 50 C.

Fast Metal Analysis

Fluorescent x-ray spectrometry, now used in the routine analysis of metals, is far more rapid than the usual chemical techniques. For example, five elements in a gas-turbine-bucket alloy normally requiring eight hours by chemical methods can now be determined in 30 minutes.

High-intensity Viewer

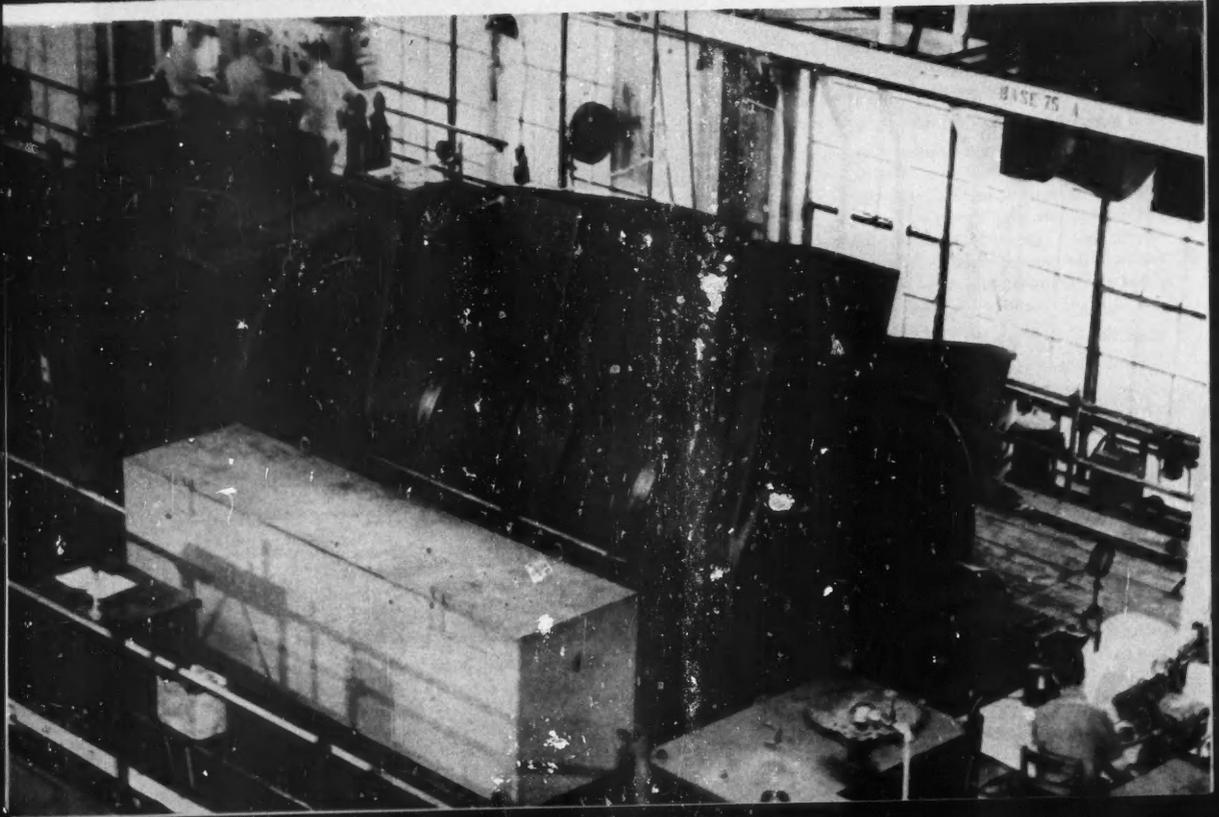
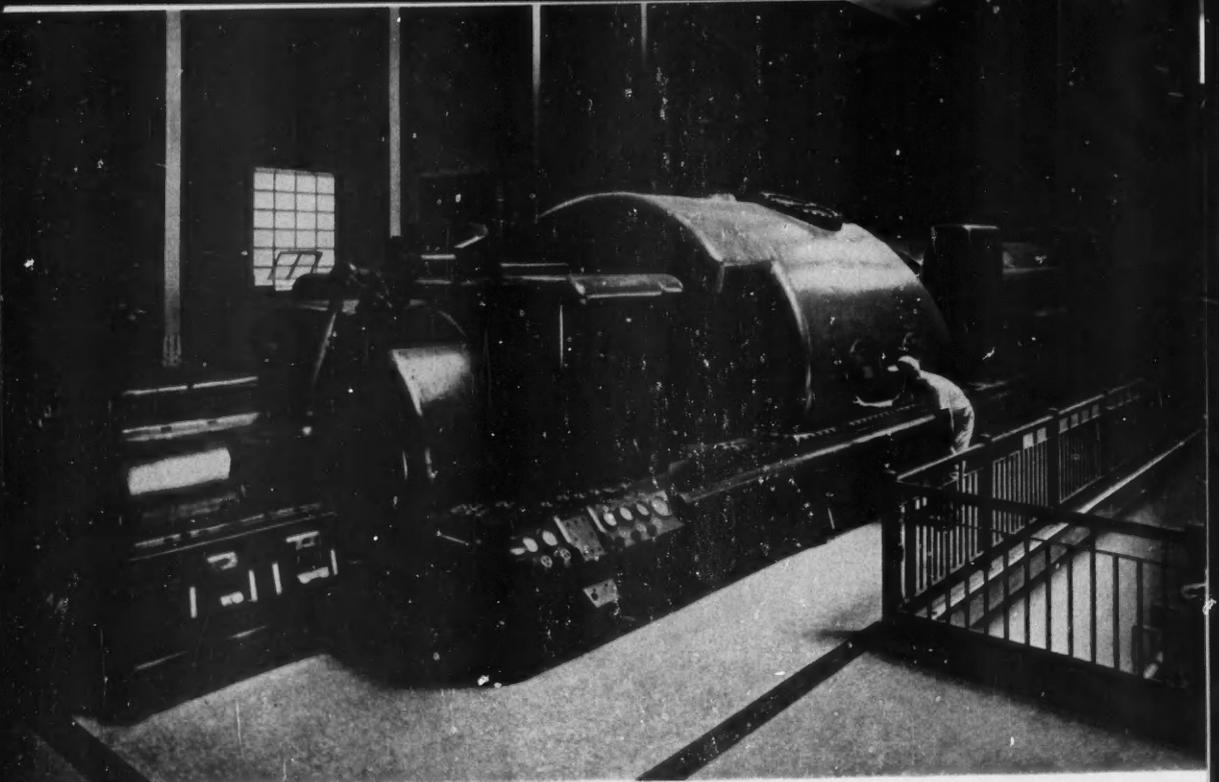
Clear images of a wide density range in industrial radiography can be viewed with a new high-intensity viewer that utilizes a special lamp of more than 100,000 candlepower. The viewer makes it possible to diagnose a radiograph of only one exposure with an object of widely varying thickness, thus reducing the need for extra exposures, and eliminating the retaking of overexposed film. Useful densities in industrial radiography vary from 0.5 to more than 4; this new high-intensity viewer is satisfactory over this wide range.



INSULATION of large rotor is checked with this winding-insulation tester



"MASCOT" exposure meter uses novel alnico magnet design for direct readings



Power

During the year the trend to larger turbine-generators continued, particularly in tandem-compound 3600-rpm units. Single-shaft machines of about 200,000 kw are on order and even larger units are contemplated. Larger power systems and the increasing number of high-capacity interconnections make it practicable to install more powerful generating units on many systems.

Steam Turbines

Reheat turbines took the spotlight in 1951. In this type of turbine, efficiency is gained by returning the steam to the boiler for reheating after partial expansion through the turbine. The reheated steam re-enters the turbine and expands to condenser pressure.

Several tandem-compound double-flow 3600-rpm units put in service during 1951 incorporate a unique design that confines all the high-temperature steam to the same region of a single high-pressure casing. These units have been outstanding for their simplicity and ease of operation.

The first tandem-compound triple-flow 3600-rpm reheat turbine was delivered to the Waukegan Station of the Public Service Co. of Northern Illinois. This unit, designed for steam conditions of 1800 psig, 1000 F initial and reheat temperatures, has a maximum capability of 121,000 kw. These larger reheat turbines have two high-pressure casings—one before and one after the point where the steam is reheated.

Thirty-five triple-flow reheat units are now on order. The Cleveland Electric Illuminating Co. will receive four such units, the first to be designed for 1050 F initial temperature. The largest are the two units for the Tennessee Valley Authority. They have a maximum capability of 200,000 kw and operate with 1050 F reheat temperature, as well as 1050 F initial temperature.

An initial temperature of 1100 F, the highest yet attained, will be used on the

two 145,000-kw units now under construction for the Public Service Electric & Gas Co. of New Jersey.

Critical alloying elements were saved by the further development of low-alloy-ferrite steels containing chromium, molybdenum, and vanadium. These show excellent strength at 1050 F and are being used extensively at this temperature for casings, piping, and valves where high-alloy stainless steels formerly were used.

In the past many turbines have been built to furnish steam for industrial processes at one or two different pressures, besides producing power. During 1951, the first triple automatic extraction steam turbine was built for the Union Bag & Paper Corp. Rated 10,000 kw, it operates between an initial pressure of 1200 psig and an exhaust pressure of two inches of mercury absolute and furnishes process steam at 400, 150, and 80 psig.

Gas Turbines

The second and third 5000-kw two-shaft compound-cycle gas-turbine power plants were placed in service in 1951 with eight additional units under construction or being installed.

Generators

The pioneer 129,412-kva 3600-rpm generator was delivered for installation at the Waukegan Station (see Steam Turbines); the first 3600-rpm generator to use eight vertical coolers. With the same length of rotor, one rated 147,059 kva at one-half pound hydrogen pressure is under construction for another utility by increasing the rotor diameter and using grain-oriented strip steel in the stator.

Five machines rated 176,470 kva at one-half pound hydrogen pressure are being built using Condal, a new aluminum alloy. The stators of these machines are so great that they must be shipped in two pieces. Double-frame construc-

tion with a flexible mounting to isolate the magnetic double frequency of the stator core is used.

Redesign of 23,529-kva hydrogen-cooled and 15,625-kva air-cooled generators has produced lighter and smaller machines. In addition, the efficiency of the 15,625-kva machine is 98 percent at full load, making it the highest-efficiency machine of this rating ever built by General Electric.

During the year extensive use was made of grain-oriented strip steel to improve the characteristics and reduce the weight and dimensions of generators. For example, the direct substitution of this steel, without redesign, reduces the core loss by almost one-third. With redesign, size and weight are proportionately reduced. The largest 1800-rpm machine to be built, a 225,000-kva 15-pound hydrogen-pressure unit, will use this steel.

Until recently voltages of large turbine-generators have seldom exceeded 15 kv. However, during 1951 several machines with higher voltages, such as 15.5, 16.5, and 18 kv, were shipped, and units with voltages as high as 20 kv are on order.

During 1951, engine-driven high-speed synchronous generators were extended to include the 950-frame sizes. Ratings now extend up to 156 kva at 1800 rpm and 125 kva at 1200 rpm.

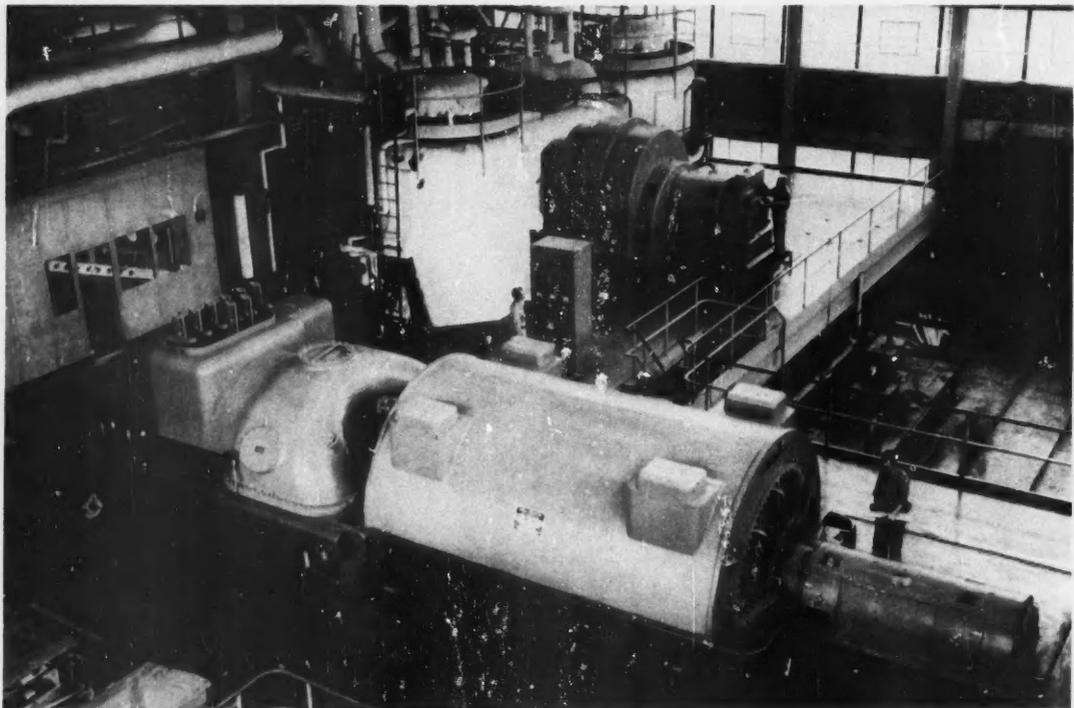
High-efficiency Station

In April the Schiller Station Mercury Unit Power Plant of the Public Service Co. of New Hampshire, which was designed and built by General Electric on the customer's mat, was tested to accurately determine the station's net heat rate. This modern power plant was completely tested with calibrated instruments and with all operating conditions held constant to close tolerances.

Results were 9,133.7 Btu per net kw-hr at a net station output of 41,419.3 kw, compared to the figure of 10,000 to 12,000 Btu per kw-hr for many plants of the same size. This high economy is believed to have established a world record for this size of plant and engineers say it demonstrates the inherently high thermal efficiency of the mercury-steam binary cycle.

REHEAT TURBINES, such as this unit, one of two at the Lee Station of the Duke Power Co., are helping generate the power for America's expanding economy

GENERATOR TEST FACILITIES at River Works, West Lynn, Mass., were expanded in 1951 to handle units to 23,529 kva over their complete operating range—from zero-leading power factor to zero-lagging power factor



MERCURY-STEAM CYCLE proved its high thermal efficiency at the Schiller Station of the Public Service Co. of New Hampshire

Test arrangements and procedures were carried out by various General Electric groups, engineers of the utility, representatives of Stone & Webster Engineering Corp., and Babcock & Wilcox Co. as well as two instructors, Robert Jodrey and Gardner Ladd, and the entire senior mechanical and electrical engineering classes of the University of New Hampshire.

Hydrogeneration

Hydraulic turbine-driven generators totaling more than 840,000 kva were shipped during the year—the most active hydrogenerator period in the history of the Company.

Orders are on hand for eight generators requiring thrust bearings capable of supporting a 4 million-pound load, the largest ever to be carried by a generator thrust bearing.

Generator-voltage Regulators

The widespread acceptance of automatic generator-voltage regulators allows

greater flexibility in electrical system design and permits many economies in generator construction. Tests at three different generating stations demonstrated that fully loaded generators could be safely operated in the under-excited region provided they were equipped with modern regulators. This factor permits greater system economies by allowing more extensive use of unswitched capacitors in the subtransmission and distribution portion of the system. In addition, the use of lower short-circuit ratio gives greater flexibility in the design of large high-speed turbine-generators and permits more economical manufacture.

Transformers

Dry-type transformers, easy to handle and install, and requiring practically no maintenance, are now being manufactured to operate at Class H temperatures with standard Class B insulation in nitrogen atmosphere. All joints are welded and without gaskets. The bush-

ings are glass with special alloy flanges welded into the transformer casing. Available in ratings up to 1500 kva, these dry-type units are especially suited to industrial plants and commercial buildings.

A small power transformer that uses less critical steel went into large-scale production in 1951. Heart of this single-phase transformer is a new precast preformed core that gives minimum core loss, exciting current, and noise level, because all the flux flows with the grain. Only one low-reluctance joint per lamination is used.

New winding-temperature equipment for liquid-filled transformers permits removal of the detecting element without de-energizing the transformer or removing the liquid.

Weight reduction of 20 to 35 percent was attained in a new three-phase Spirakore* distribution transformer. These transformers, in ratings up to 150 kva, take up less floor space and are shorter

*Reg. trade-mark of G. E. Co.

in height than previous designs. A clamp band replaces the conventional J-bolt construction and produces uniform gasket pressure around the cover rim, resulting in better sealing.

A reduction in size and weight of approximately 25 percent, with a consequent saving of copper, was made possible by converting air-cooled specialty transformers in ratings of 3 kva and above to use Class B insulation.

For the first time in instrument transformer history a single design for both indoor and outdoor installations was made available. This 600-volt window-type current transformer features molded butyl-rubber insulation; it is compact enough to meet standard mounting dimensions for indoor applications and is completely weatherproof for outdoor service.

Bushing-type current transformers in the lower-current ratings, with accuracy comparable to that of wound-type current transformers, have been made possible through the application of a new compensating principle. In the "orthomagnetic" design the core excitation losses are mostly supplied from a separate source by superimposed excitation at higher than normal frequency; thus the error at normal frequency is largely eliminated.

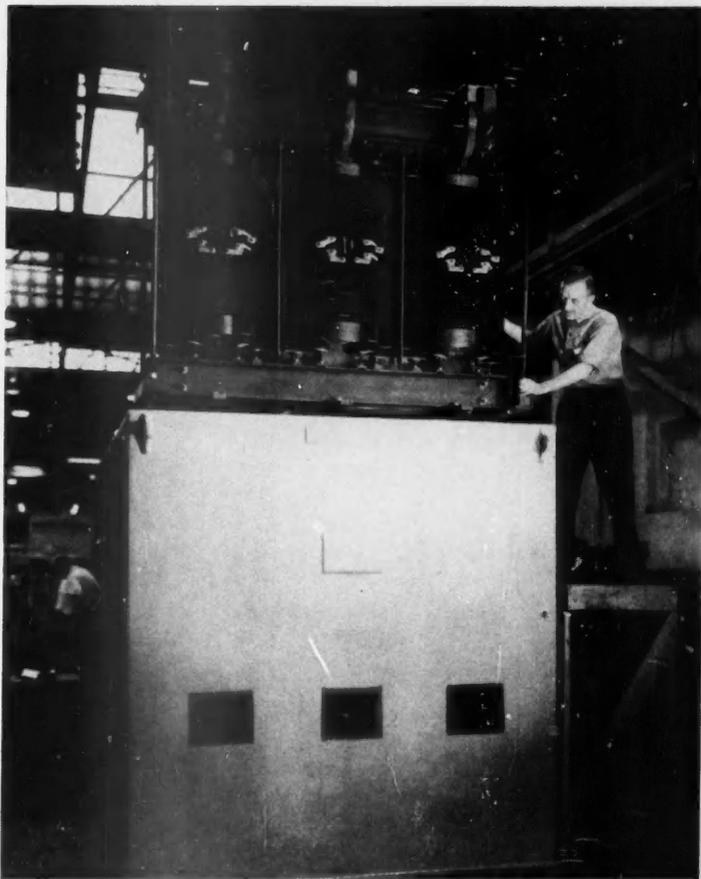
Development of a new compact tap changer for de-energized operation, particularly in autotransformers where it is often desirable to change taps at the line end of the winding, was announced in 1951. Permitting some reduction in the size and weight of the transformer, the tap changer eliminates the disadvantage of having maximum voltage across adjacent contacts.

During 1951 two outdoor current-limiting reactors—the largest three-phase oil-immersed reactors ever built by General Electric—were shipped to a Midwest utility. The units are rated 7170 kva, 2985 volts, and 800 amp.

Switchgear

Metal-enclosed high-voltage air-blast circuit breakers moved outdoors for the first time during the year when 69-kv equipments were installed on the Consolidated Edison system in New York. Rated 3500 mva, 2000 amp, each breaker consists of three completely isolated single-phase units.

Each pole has two air-blast interrupters in series. The first interrupter to open is shunted by a resistor; the

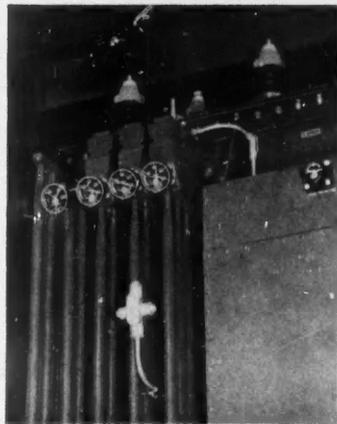


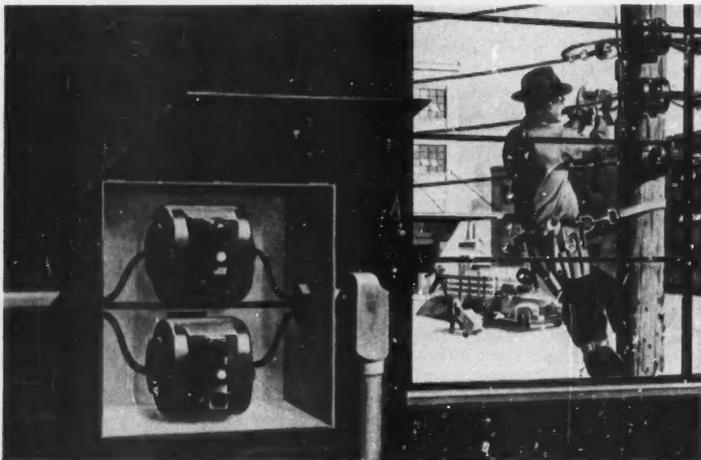
TANKING a sealed dry-type transformer rated 750 kva. Units like this are easy to handle and install; they are especially suited to industrial plants and commercial buildings

second opens a fraction of a cycle later to open the circuit through the resistor, thus completing the interruption, which is successful even on systems having unusually high recovery-voltage rates. An internal contact rod, withdrawn from between the interrupters immediately following interruption, provides the required open-break distance sometimes achieved by external contacts. The operating assembly is mounted on wheels so that it may be disconnected and pulled out for servicing.

Air-blast circuit breakers for furnace applications in the 25- to 34.5-kv ratings were made available to elim-

DETECTING elements of these winding-temperature equipments may be removed without de-energizing the transformer





inate the problem of oil contamination that is always present with oil interrupters. The solenoid operating mechanism included in the new design fulfills the demand for a breaker with long mechanical life under the stress of continuous repetitive service.

A new insulating material possessing excellent flame-retardant, dielectric, and antihygroscopic properties is used extensively in the magne-blast circuit breakers and other parts of a new design of metal-clad switchgear. The design also stresses interchangeability of parts among the various ratings and includes an improved breaker and operating mechanism with an integral control device, and a fast, simple elevating mechanism with positive mechanical interlocks and flame-retardant barriers between units in the bus compartment.

A serviceable silver contact surface for aluminum bus bars—equal to that of copper with silver contacts—was developed during the year. Factory equipment now plates the silver on aluminum to any desired thickness. The silver is so thoroughly bonded that the contacts meet all requirements for contact stability and resistance to corrosion at all operating temperatures.

Vertical and side-break outdoor disconnecting switches were designed with a simpler operating mechanism that gives superior ice-breaking qualities. Silver-coated ball bearings in the side-break switch serve the dual purpose of a low-friction blade-rotation bearing and a means of carrying current.

Renewable fuses with time-delay features for low-voltage circuits now have silver contact surfaces; burned out links are removed by unscrewing one cap and withdrawing the link holder from the casing.

Relaying

Equipment for the first application of protective relaying over a microwave channel is under construction. To protect a tie-line between two East Coast utilities, the 960-mc channel will also be used to provide transferred trip for differential relaying of the transformers

REDUCTION in weight of three-phase Spirakore distribution transformers was realized with new core construction

BUTYL-TO-METAL sealing technique makes possible the use of this new current transformer either indoors or outdoors

at both ends of the line. One two-way voice channel will be provided, in addition to high-speed tones above the voice band for the relaying functions.

A method of back-up relaying for transmission lines was made available. It circumvents the limitation of previous schemes caused by multiple feeds to the bus. With the new method, failure of a breaker to clear results in tripping all the breakers connected to the same bus instead of depending on relays at the far ends of all other lines.

Four 115-kv transmission lines from a large new steam station will be protected by a combination of carrier-current relays consisting of directional-comparison relaying for multiphase faults and phase-comparison relaying for single-phase-to-ground faults. Only one single-frequency carrier channel will be used for the combination.

A new line of dual-polarized ground-directional relays can be used with either current or potential polarizing sources or both. Thus a single relay will cover applications formerly requiring two, and one spare relay can be used in both types of installations.

New Unit Substation

A new unit substation for subtransmission service was developed to receive transmission power at 69 to 138 kv for subtransmission at 13.8 kv in blocks as high as 75,000 kva. The substation is of the completely outdoor type and has super-fan-cooled transformers and 13.8-kv metal-clad switchgear arranged for "building-block" expansion.

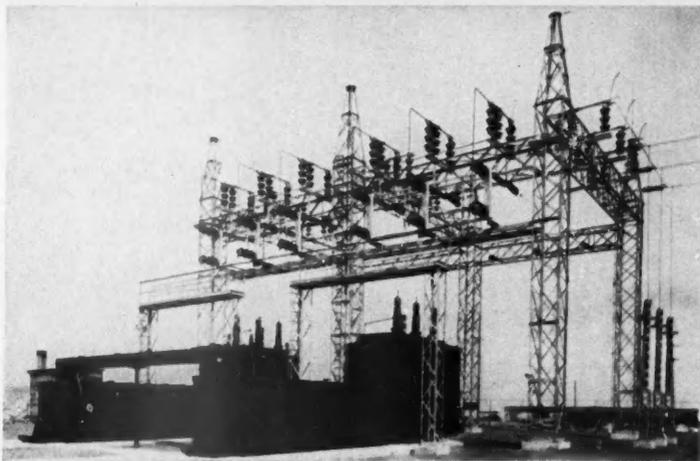
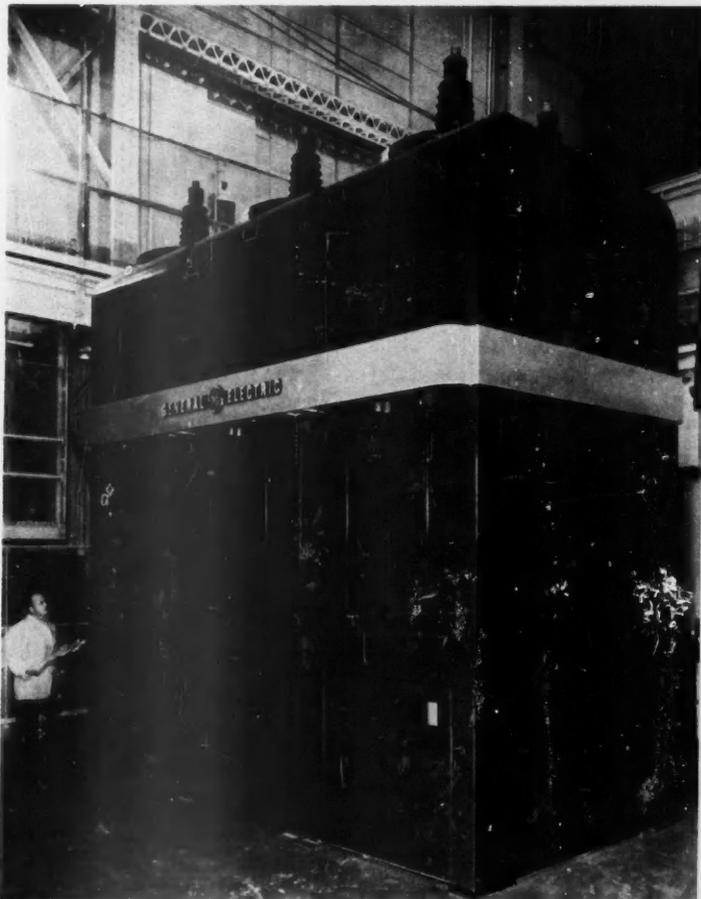
Capacitors

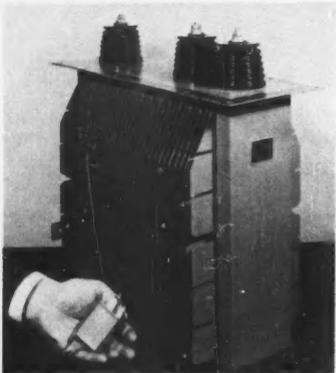
The use of capacitors connected directly to circuits above 15 kv increased tremendously in 1951. Where magnetizing kilovars are needed on these high-voltage circuits, the economics are in favor of this method. It is estimated that in the year 250,000 kilovars of equipments at voltages from 23 to 115 kv were shipped or placed on order. The largest equipment is rated 24,750 kvar, 108 kv.

Tailoring the design of capacitors—as well as reducing their size and weight

AIR-BLAST BREAKERS rated 69 kv, and metal-enclosed for outdoor operation, were placed in operation during 1951

●
SUBTRANSMISSION substation was developed to receive power in 69- to 138-kv range for subtransmission at 13.8 kv





LIFE-TEST program tailors the design of the capacitor to the application—for land use or for guided missiles



RADAR CABLE for outdoor portable equipment is tested in special rooms at -65 F. At the other extreme, this same cable is able to withstand temperatures of $+135$ F

—to the life requirements of radar equipment has become possible through an extensive test program. Life requirements of pulse-forming capacitor networks for aircraft and guided-missile radar range from 10 to 10,000 hours.

Small d-c capacitors in low-voltage ratings suitable for operation between -55 C and $+125$ C were developed. Impregnation with permafils, a distinctive solid dielectric, makes applications possible under unusually high or low temperatures, or both.

Cable

In all ranges of pressure and voltage gas-filled cable gained in popularity during 1951.

The Pacific Gas & Electric Co. in San Francisco installed a large quantity of

120 kv 200 psi pipe cable, using a medium-viscosity impregnant.

Medium-pressure gas-filled cable operating at 40 to 50 psi pressure was installed by the Potomac Electric Power Co. in Washington, D. C.

Large installations of low-pressure 15-kv cable were made by the Cincinnati Gas & Electric Co. and the Indianapolis Power & Light Co. In a 15-kv installation made by the Public Service Electric & Gas Co. of New Jersey, the gas pressure is also used to give pressure supervision of the subway-type network transformer tanks by means of gas connections from the cable to the transformer tank. This feature avoids transformer failures due to entrance of moisture through any leaks that might develop.

Accelerated life tests on gas-filled cable in a vertical position showed that after drainage of surplus compound a stable condition was reached with plenty of compound left in the insulation for impregnating purposes. Also, there was no change in ionization voltage. This contradicts a former belief that such conditions would eventually leave the insulation dry, enlarging voids, and materially lowering the ionization voltage.

These laboratory findings were confirmed by examination of lengths of a 69-kv gas-filled cable that were removed after service on the Philadelphia Electric Company's system.

For a recent 120-kv high-pressure gas-filled pipe-type cable installation, joints were supplied that eliminated considerable field cutting and welding. The new arrangement allows a free gas path past the semistop in the joint end case after the joint is completed, and also permits the gas path to be closed during construction.

During 1951, radar cable for outdoor portable equipment for the U. S. Air Force was developed to withstand temperatures ranging from -65 to $+135$ F.

Aluminum interlocked armor cable is now available in addition to the conventional types. To provide extra-fast installation, aluminum-alloy cable racks that look like ladders make it possible to support a number of cables without using individual hangers.

Corona-detecting equipment capable of testing full-reel lengths of cable was developed in 1951, and every foot of 15-kv cable manufactured was tested for corona level in addition to the standard industry tests. When an air void is present in a cable, it will ionize if the

voltage stress across the void is sufficiently high. The small remitting impulse is visually reproduced on an oscilloscope.

The measurement of oil volume in a balanced-pressure reservoir, always a rather exacting operation, was made easier by a new indicator that determines the correct oil volume, can be used at any time, and does not change the reservoir setting in any way.

Rectifiers

A selenium rectifier no larger than an aspirin tablet is saving scientists a lot of headaches. Used to power mammoth computers, the miniature cells play a vital part in solving mathematical problems for the armed services.

The largest single G-E installation of water-cooled copper-oxide rectifiers was completed during the year at a large Eastern manufacturing plant. The new units are used for plating and furnish a total current of 200,000 amp.

Bushings

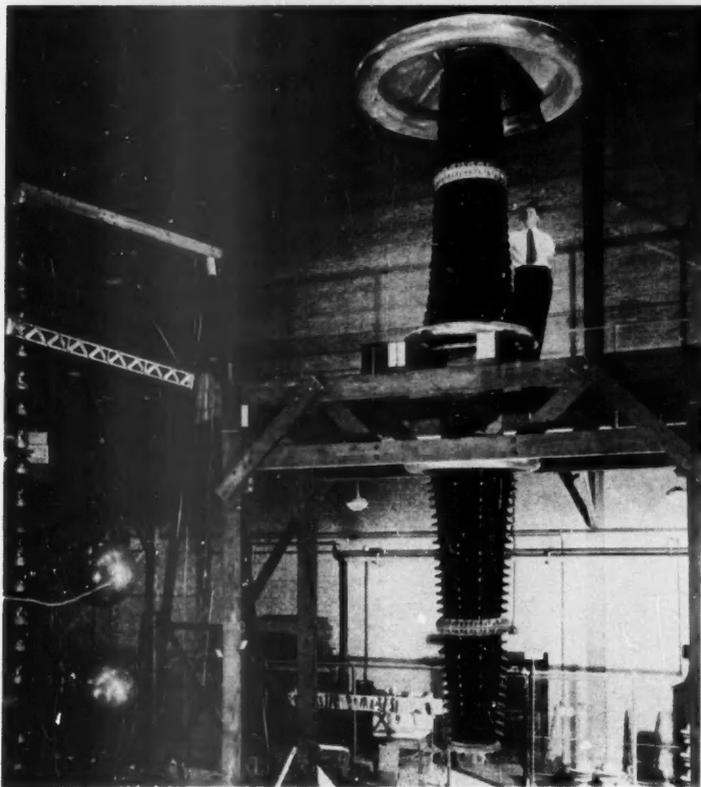
Thirty-nine of what are believed to be the largest one-piece dry-type roof bushings were built during the year by the Locke Department of General Electric. Rated 23 kv, 7000 amp, the porcelain were extruded from the world's largest vacuum pug mill. Over-all dimensions are 41½ inches long and 20½ inches over the petticoats on the outdoor end.

Insulator string assemblies for operation on the American Gas & Electric Service Corporation's 315-kv test line—the highest voltage yet used in this country—were designed and built in 1951. Tests showed that the insulator assembly—using a novel design of corona shield—is equal in corona suppression under all conditions to that of the conductor itself.

Another bushing development was a sample for the U.S. Navy of a unit to operate at low-frequency radio voltage up to 300 kv. The 26-foot bushing will be gas-filled to keep dielectric losses low. A combination rain, falling-ice, and corona shield 8 feet in diameter is mounted on the upper terminal of the bushing.

CORONA-detecting equipment tests full-reel lengths of high-voltage cable

RADIO-FREQUENCY bushing for the Navy is 26-feet long; operates at low radio frequency up to 300 kv



Industry

In 11 years, from 1939 to 1950, American industry increased its use of power from 81.2 to 189.7 billion kilowatt-hours—134 percent. In the same period the industrial production index went up 83 percent. This means that industry is now using some 27.5 percent more energy per unit of production—a clear indication that the process of supplementing manpower with electric power continues at an accelerated rate.

Industry relies more and more on purchased power. In 1939, industry generated 37.5 percent of the power that it used. In 1950, this figure dropped to 27.5 percent. The present emergency conditions, however, may temporarily distort this long-range trend.

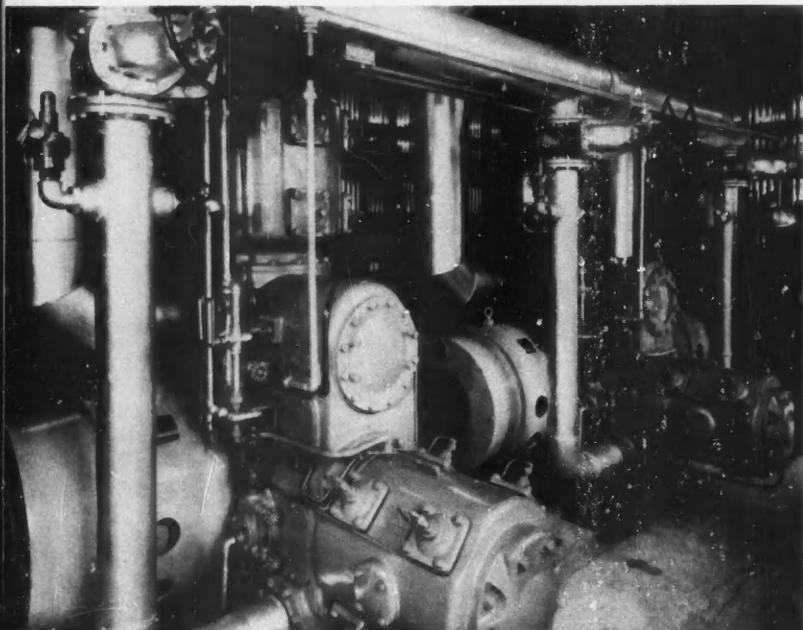
Motors

Two 65,000-hp synchronous motors—the world's largest—were installed last year in the pumping plant at Grand Coulee Dam. Each motor stands 25 feet high and weighs more than 330 tons. They are used in the Bureau of Reclamation's Columbia Basin Irrigation Project under a program designed to help irrigate a vast expanse of rich but dry land in the south-central part of Washington state. They drive two of the world's largest pumps, each supplying enough water to equal the daily needs of New York City. When operating under optimum conditions, each pump supplies more than a billion gallons of water a day (50 tons a second).

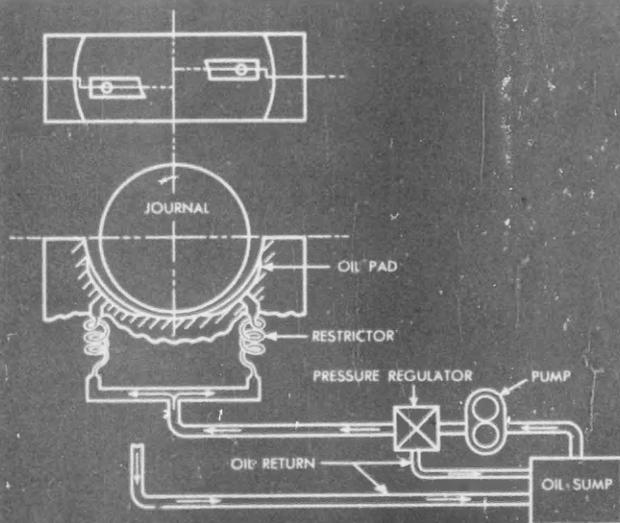
To hold breakaway torque to a minimum, the thrust bearings are designed for high-pressure oil lubrication during starting. To accomplish this, oil is forced between the bearing surfaces through a special inlet in each segment of the stationary plate.

Production was started on a new line of aircraft gear motors in ratings from 1 to 4 hp for use in electrohydraulic actuators. Precision-gear design and manufacture with new means for oil lubrication provides higher ratings in small sizes. Liberal use of steel inserts in the aluminum housing assures adequate strength at all highly stressed points, excellent gear and mounting alignment, and light weight.

A new low-cost 150-watt radio dynamotor is now in production for auto-



ROUND-FRAME synchronous motors are mounted directly on the frame of the air compressor; thus no special motor foundation is required during installation



OIL FILM separates the bearing surfaces on this dynamometer trunion-bearing arrangement. Life is prolonged and measurement error reduced

motive service to provide 400 to 700 volts d-c for taxicab and police-cruiser transmitters.

A quieter more efficient synchronous motor was developed for recording instrument drives. The new design eliminates most of the special parts and such critical materials as ball bearings and chrome magnet steel; nearly all components are the same as those used in standard business-machine motors.

For defense applications, there's a new 110-volt 400-cycle hysteresis-type synchronous timing motor for use in a compact 1½-inch panel-instrument elapsed-time indicator, Type ET-1, designed primarily to fill a gap in the military needs for maintenance of auxiliary equipment. The gear reduction, contained within an axial space of about 1 inch, is 1,728,000,000 to 1.

Development of an alternating-current polyphase motor whose speed can be finely controlled makes it possible for the synthetic-fibre industry to gain the benefits of precise speed control without more expensive d-c drives and a-c to d-c conversion equipment. Developed for nylon extruding machines, the new motor is coupled to an alternating-current generator to provide adjustable frequencies which vary less than 0.1 percent within process requirements. The fine speed control was accomplished by adding ball-bearing spring-loaded brush holders and electronic control to the General Electric Type ACA adjustable-speed brush-shifting induction motor.

A line of round-frame synchronous compressor motors was developed in ratings from 75 to 250 hp for close coupling to a new line of self-contained air compressors. Because the motor is mounted on the frame of the compressor, no special motor foundation is required during installation.

In locations where hazardous carbon black is present—the rubber and plastics industries—the trend has been to totally enclosed motors. During the year an 800-hp 2300-volt 720-rpm synchronous motor was built for the Good-year Tire & Rubber Co. Designed with an air-to-water heat exchanger, the new motor eliminates cumbersome cooling ducts and the blower and motor required for forced-ventilated motors.

One of the most important improvements in magnet wire for motors is the new Type D/A asbestos-insulated wire that offers superior flexibility and

consistently higher dielectric strength with smaller insulation thickness than previously possible with any type of asbestos-insulated wire.

Dynamometers

A radically different and improved trunnion-bearing arrangement was developed for three of the more popular dynamometer frame diameters. Replacing the antifriction bearings that permit rotation of the dynamometer frame, the new bearing consists of two mating hardened-steel surfaces always separated by a film of oil supplied at high pressure by an external oil system.

Because there is no metallic contact under any operating condition, the new system makes possible a torque measurement error from trunnion-bearing friction of less than 0.0005 percent compared to the usual 0.05 percent. The life of the trunnion bearing is indefinitely long, thus correcting the short-life troubles that have plagued the industry for years.

A group of high-speed d-c machines were built in 1951 for operation as

block-test dynamometers or high-speed d-c motors or generators. The largest is rated 650 hp as a generator and 500 hp as a motor over a speed range of 1500 to 4500 rpm with constant-torque operation from 1500 rpm to standstill. The units are externally ventilated, have oil-lubricated ball bearings, and feature the enclosure of all auxiliary ventilating and lubricating equipment under removable covers.

Control

A completely new voltage regulator and static exciter were developed for use with auxiliary generators on Navy ships and other synchronous machines. The regulator includes three stages of magnetic amplifiers and the newly developed magnetic current reference; the static exciter employs saturable current transformers, reactors, and transformers—it eliminates the rotating exciter.

Continued emphasis on safety is the feature of a complete line of devices for the control of domestic oil-burning furnaces that was placed in production in 1951. The line consists of a master-

CONTROL CABLE uses open-mesh glass tape over the conductors for increased moisture resistance. This construction feature eliminates any "wick" action



control unit for control of the oil-burner motor and ignition transformer; limit controls for steam and hot-water boilers and warm-air furnaces to limit operating temperatures and pressure; and a room thermostat for control of the over-all system. In case of flame failure, the master-control unit shuts down the oil-burner motor.

A new refrigerator temperature control, approximately half the size and two-thirds the price of the superseded design, was put in quantity production during the year. The new design provides all necessary functions of temperature adjustment, defrost, and Off operation with a snap-action mechanism of unusually simple construction.

Contactors and Starters

A line of low-voltage high-current contactors designed for use on battery-operated lift trucks is in production. The contactors are small and compact to fit into the small space available on mobile equipment.

New magnetic contactors and starters were put in production in sizes 0, 1, 2, and 3 by the Trumbull Electric Department of General Electric. The line consists of a basic unit in each size so designed that standard accessories—such as interlocks, transformers, extra overload relays, and other parts—may be readily added to cover a wide range of applications.

Control Cable

An all-silicone ignition cable that possesses excellent electrical properties even after prolonged immersions in petroleum hydrocarbons was designed and put into production in 1951. Capable of operation through a temperature range of -65 to $+450$ F, the cable has a stainless-steel conductor with an insulation of silicone rubber, a reinforcing-glass-fiber braid, and an overall sheath of silicone rubber.

Another development was a 30-volt low-tension cable designed for communication, lighting, and gun-fire control circuits of all military vehicles and tanks. Construction consists of a flexible copper-stranded conductor, high-grade natural rubber insulation, open glass-fiber-reinforcing braid, and a low-temperature flame-retardant neoprene sheath. These cables are also resistant to petroleum hydrocarbons, as well as fungus growth, and will withstand mechanical abuse at temperatures as low as -65 F.

Increased moisture resistance is one of the features of a newly designed multiple-conductor control cable utilizing an open-mesh glass tape over the assembled conductors. The mesh tape allows the geoprene jacketing compound to be extruded through the openings, thereby giving the effect of rubber-like fillers in the outer interstices. This construction eliminates the drawing of moisture into the cable by "wick" action as is sometimes the case with jute fillers.

Industrial Heating and Welding

The world's largest continuous tinplate annealing furnace was placed in operation during 1951 at the Gary Sheet and Tin Mill Division of the United States Steel Company. It has a rated output of 30 tons per hour and a maximum strip speed of 1000 fpm; a protective inert-gas atmosphere during the heating-and-cooling cycle preserves the bright oxide-free surface of the tinplate. All motors and control for the strip-handling equipment were supplied and co-ordinated with the furnace equipment by General Electric.

Radical redesign of 30-volt direct-current welders reduced their weight 25 percent and gave improved results. Theoretical analysis supplemented by oscillographic studies showed that a solid-core reactor in the circuit gives better performance than a laminated-core reactor. The solid core broadens the time base of the inductive-voltage kick following incipient arc instability. This permits the reactor to sustain voltage during the short interval required for build-up of the generator fields.

Mining

The mechanization of coal mines rapidly increased during the year. Special motors—delivering high power output in a small space—were used on a continuous mining machine that digs coal without prior undercutting or blasting, and practically doubles the average output per miner.

General Electric developed a "shuttle car" for carrying coal from the working face to the main haulage way. Mounted on caterpillar tracks, and powered from a stationary source of electricity by means of a trailing cable, this car has the greatest ratio of load-weight capacity to car size yet constructed. It uses a separate 20-hp motor for each track,

two 5-hp motors for the coal conveyor, hydraulic devices to operate the cable reel, and steering brakes and elevating mechanism for the discharge conveyor.

With the supply of rich ores dwindling, and with steel mills expanding, the iron-ore industry began to tap the vast resources of low-grade ores (taconites). This ore must be crushed and concentrated before shipment to steel plants; the operation requires about 70 to 80 kw-hr per ton of concentrate compared to 4 to 5 kw-hr per ton of rich ores. Not only is there a new and large demand for electric power but also for equipment for the efficient distribution and utilization of electric power.

Steel and Other Metals

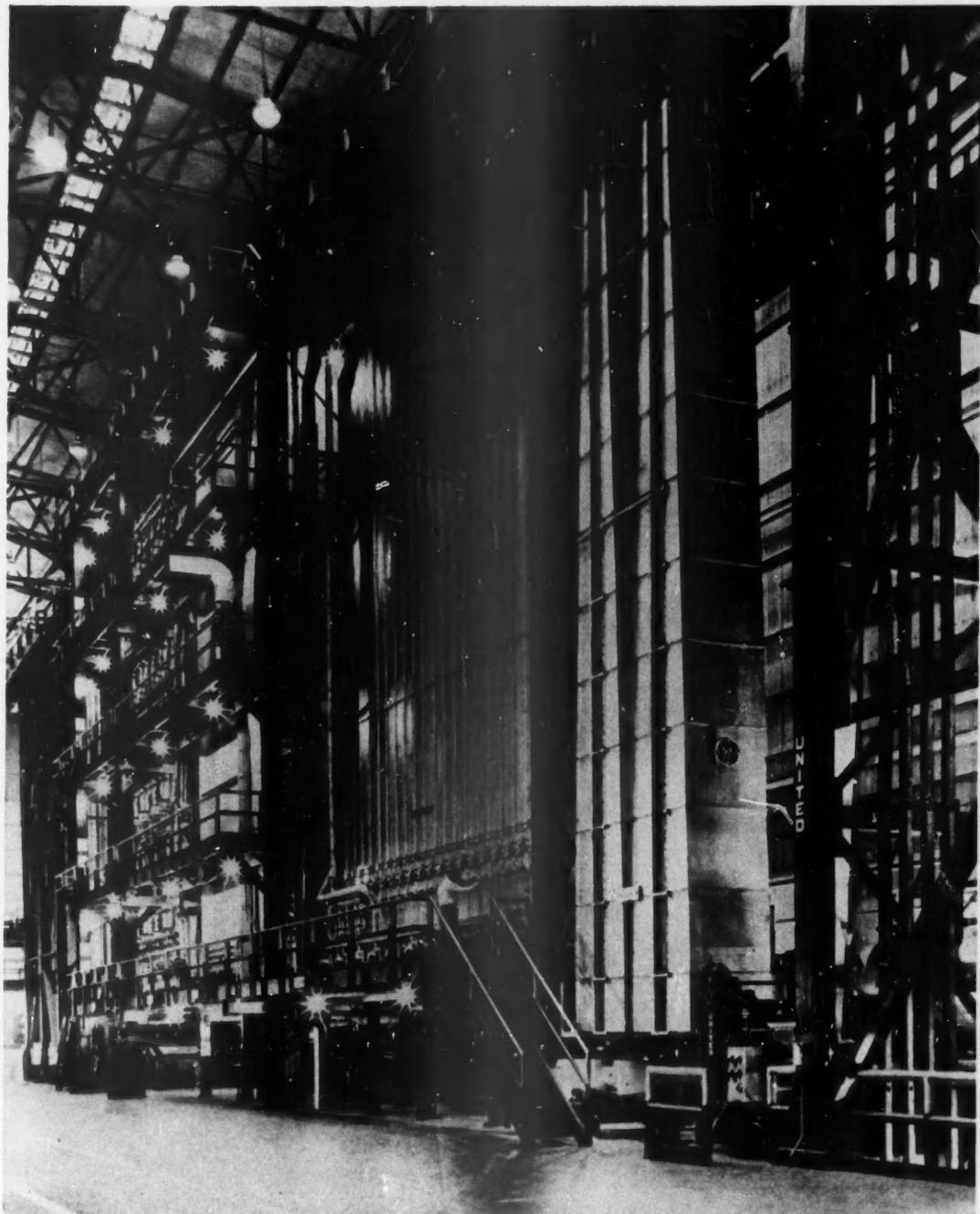
Steel mills have rapidly increased their output by some 20 percent in two years. This expansion includes the output from blast furnaces, steel-melting furnaces, rolling mills, and steel processing.

Electric arc-furnace tonnage increased more than fourfold in the last ten years and now accounts for about eight percent of total steel production. This figure is fast growing because of improved electric furnaces, increased fuel cost, and low power rates—factors that make electric steel cost competitive with open-hearth steel.

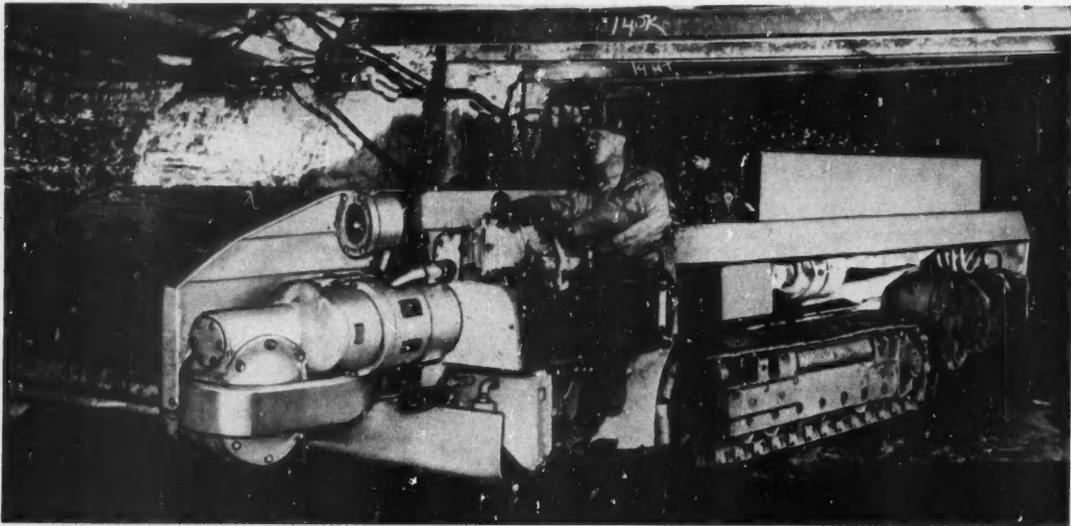
Equipment for the world's fastest cold-strip mill was shipped last year to the new Fairless Works of the United States Steel Corp. near Morrisville, Pa. The five-stand mill will roll tinplate 30 inches wide at a record-breaking speed of 7000 fpm. Power for more than 21,000 hp of main drive d-c motors is supplied by two separate motor-generator sets, one driven by a 14,000 hp, the other by a 10,500 hp synchronous motor. A triple-armature twin drive, the first of its type ever built, drives Stand 5.

In 1951, shipment was also started on the main-drive motors and MG sets for a four-stand cold-strip mill for the same plant. This 80-inch mill operates at 3120 fpm and is driven by the same total motor horsepower as the five-stand mill.

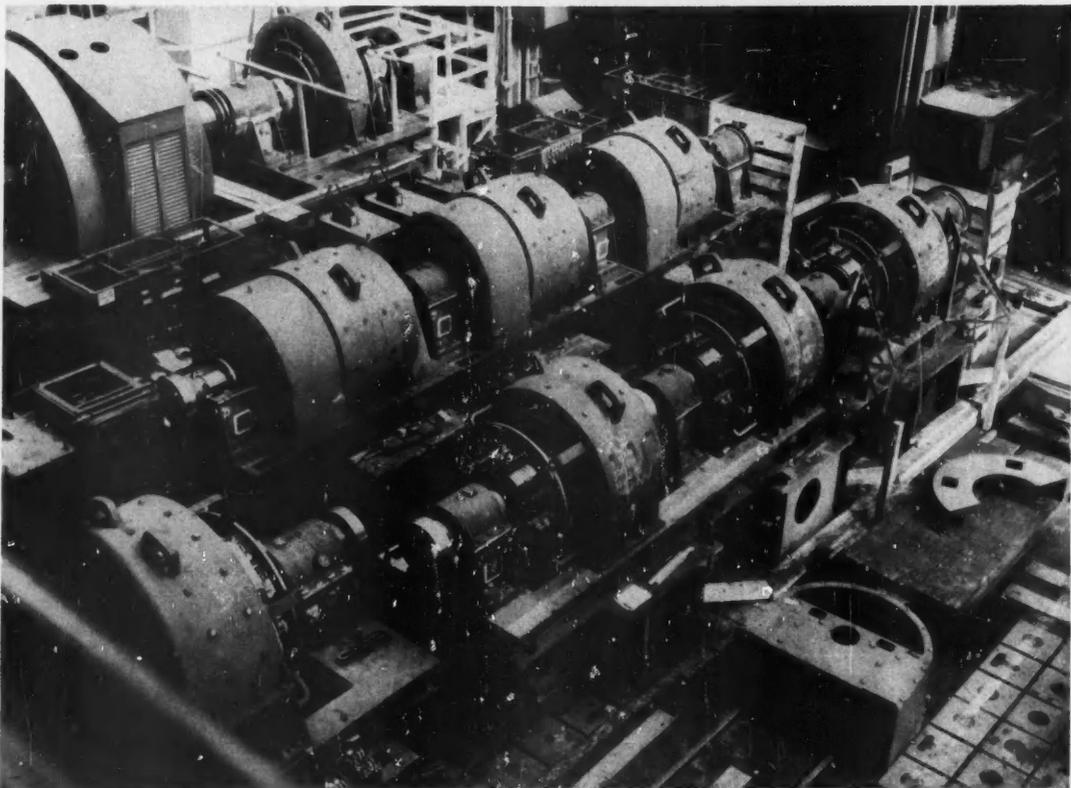
Design engineering proceeded on a 12,000-hp d-c drive that will replace a steam engine on the famous blooming mill at the Aliquippa, Pa., plant of the Jones & Laughlin Steel Corp. This mill holds the world's record for production of blooms, having rolled 183,728 tons from five-ton ingots in March, 1949. Engineers predict that electrification of



WORLD'S LARGEST annealing furnace continuously anneals tinplate at a maximum strip speed of 1000 feet per minute



MINE SHUTTLE CAR carries coal from the working face to the main haulage way. It has a capacity of 190 cubic feet



TRIPLE-ARMATURE twin drive—first of its type—on test. Complete five-stand mill will roll tinplate at 7000 feet per minute

this mill will make it possible to equal or better the previous performance.

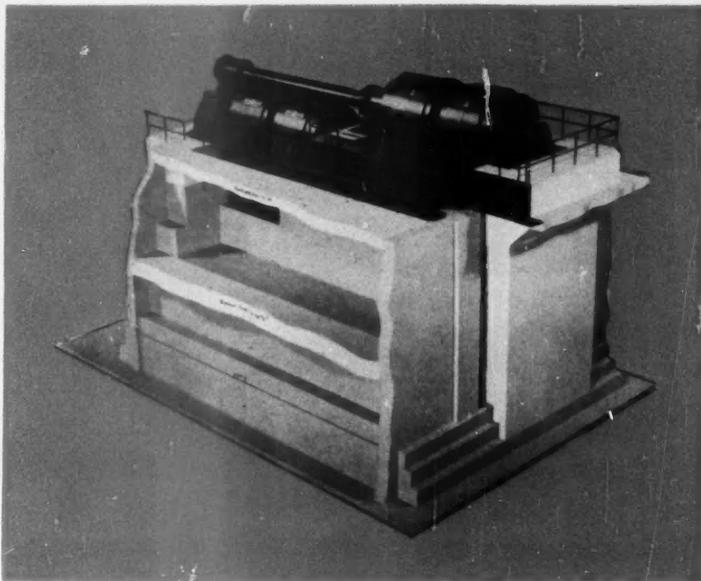
The main-drive motors are arranged for twin drive, with a 6000-hp double-armature unit connected to each of the two drive rolls. The low rotor inertia that this makes possible is necessary as the main-drive motors are designed to reverse from base speed to base speed in approximately one second; normal requirement is two seconds for mills of this type. Power for the drive will be furnished by a 12,000-kw flywheel motor-generator set.

A twin-tandem motor drive for a two-stand temper mill was built for Jones & Laughlin Steel Corp. The 600-hp 1150/1500-rpm motors, each consisting of two 300-hp armatures, provide independent drives for the upper and lower work rolls of Stand 2. Drive is direct to the work rolls through spindles having universal joints at both ends; thus the shaft spacing must be approximately the same as the diameter of the work roll. To meet the 18½-inch shaft center-to-center distance, a special six-pole electrical design using an unusually small-diameter armature with long stacking was used. Short pole pieces with field coils wound directly on the poles, together with the thinner frame permitted by the six-pole design, made possible a frame of minimum diameter.

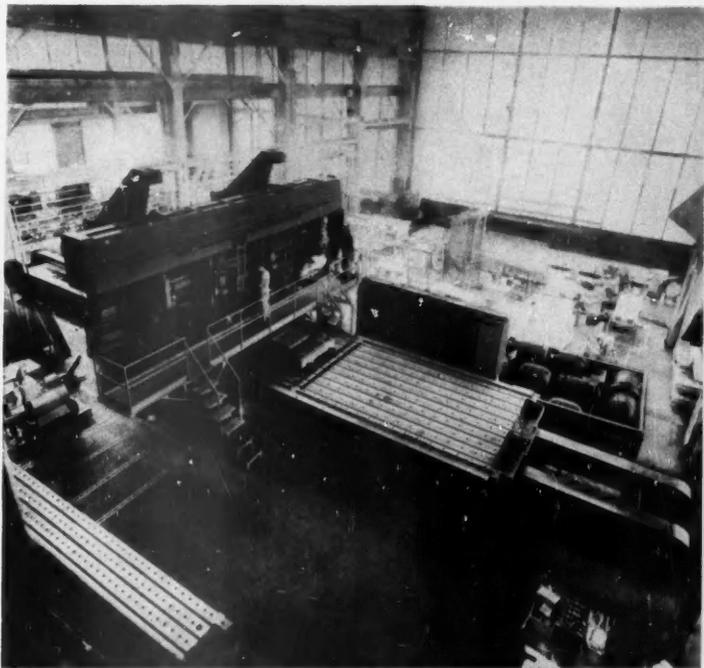
Other Metals

Aluminum production, stimulated primarily by aircraft requirements, is growing at a record-making pace. From 1,400,000,000 pounds per year capacity in 1949, the goal is 2,200,000,000 pounds for 1952. It takes about nine kilowatt-hours of d-c power per pound of aluminum; thus an additional demand of 800,000 kw is indicated. Since low-cost hydroelectric power is not readily available in the necessary amount, the industry has turned to natural gas to fill a part of this demand for power. More than 350,000 kw of this additional capacity was provided by gas engines driving d-c generators. Units of 1100 to 2500 kw are used. Aluminum pot lines as large as 100,000 amp at 750 volts are under construction, and it is expected that even before the present expansion is completed another similar one will be authorized.

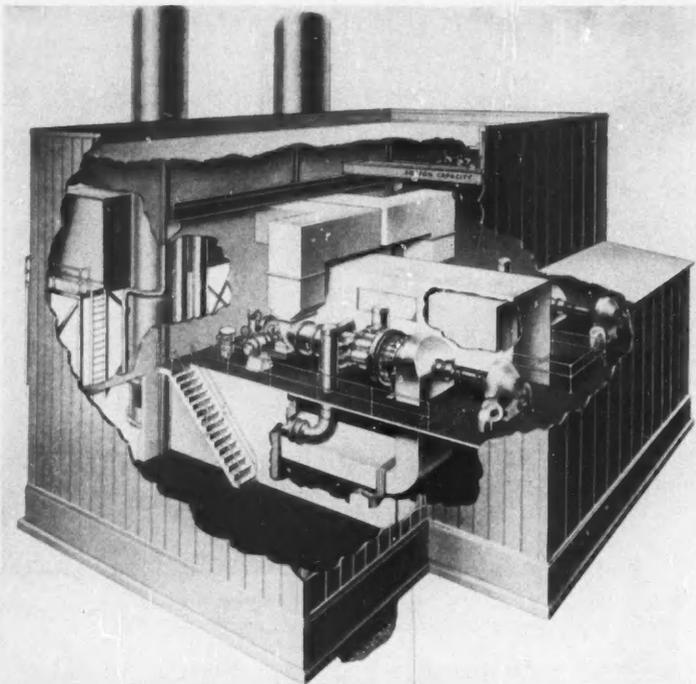
Production of chemicals, such as chlorine, sodium, phosphorus, ferro-alloys, and others, is steadily and rapidly growing. This creates a large



MODEL OF TWIN-DRIVE 12,000-hp unit that will replace a steam engine on Jones & Laughlin Steel Corporation's famous blooming mill at Aliquippa, Pa.



WING SECTIONS for jet planes are machined from large aluminum plates on this new "skin miller." Electric drive and control were furnished by General Electric



BOOSTER STATIONS on many natural gas pipelines will use General Electric gas turbines to move this high-grade fuel from the Southwest to industrial areas

demand for rectifiers for electrochemical processes and for large transformers used for electric furnaces. A 25,000-kva transformer—one of the largest units of this type ever built—has been installed on a phosphorus furnace.

Manufacturing Industries

Machine tools—machines that make machines—became more elaborate, more specialized. Automatic contour-follower control and multiplicity of adjustable drives per machine are but a few of the requirements to speed the manufacture of aircraft frames, jet engines, and other defense and civilian items.

Heavy orders in 1951 for electric furnaces for heat-treatment of manufactured articles proved the economy and high quality of this production tool.

For large printing presses a drive consisting of d-c motors backed by adjustable-voltage rectifiers gained wide acceptance. A similar drive was ordered for two sugar tandem mills.

The demand for paper continues high, reflecting the growing need for containers, newsprint, and other such material for the economy. Many new high-speed sectional paper machines were installed, are under construction, and on order. Precision electronic-amplidyne speed regulators to keep the machine sections in step have become the industry's standard.

The first commercial application of ultrasonic cleaning units on a manufacturing production line was made in 1951 for Schick Inc. for use in degreasing electric shaver cutters after machining. Lapping compound and other oils are cleaned from the cutters by the use of ultrasonics more quickly and more effectively than by the use of cleaning solvents alone.

Materials Handling

Gas turbines will be used at booster stations of natural gas pipelines to move this high-grade fuel from the Southwest to industrial areas. Since electric power

is not always available at the booster-station location, the idea of using a G-E gas turbine was attractive. For instance, the El Paso Natural Gas Co. ordered 28 gas turbines for their main trunkline between West Texas and California. Each unit is rated 5000 hp and will drive a direct-connected centrifugal gas compressor at 5000 rpm. Drawing their fuel right out of the pipeline, and requiring no water, the units are completely self-contained. A regenerative cycle is used; the inlet temperature at the first stage nozzle is 1450 F. The 11 booster stations are laid out to permit their operation by automatic supervisory control.

Modernization of motor-generator sets for shovels and draglines was completed during the year. Many standardized parts are used along with mechanical improvements such as increased bearing and shaft sizes, more rugged frame and bearing-housing assemblies, and heavier mounting brackets for ammeter shunts. At the same time this line of generators went into production, a program was started with shovel builders to review required ratings as well as other mechanical redesign items on their shovels. As a result of this program, 11 of the most popular shovels and draglines were modernized.

Increased ore tonnage from the Lake Superior region necessitated expansion of railroad ore-unloading facilities at lower Great Lakes ports during 1951. Development of new ore fields in South America and Labrador accelerated construction of ore unloaders by railroads on the Eastern seaboard.

Power for the new Baltimore & Ohio Railroad import ore pier at Baltimore is supplied by two 1000-kw 250-volt d-c pumpless ignitron rectifiers—the first application of such equipment to the highly fluctuating loads of a port facility. The rectifiers power two 17-ton man-trolley-type ore unloaders, conveyor belts, and 40-ton electric pusher locomotives for handling gondola cars under the weighing hoppers.

At Toledo, Ohio, the Lakefront Dock & Railroad Terminal Company initiated an expansion project that will add two new Hulett unloaders and increase existing capacity. The new unloaders will apply adjustable-voltage drive to a rated 20-ton bucket. Three additional 40-ton electric pusher locomotives for use in manipulating the cars under the unloaders are required to handle the increased tonnage.

Marine

Redesigned 500-kw and 750-kw 1200-rpm turbine-driven generators were built giving weight reductions of 39 and 25 percent respectively, including coolers. This was accomplished by applying axial ventilation to these large sizes for the first time, and by fully utilizing the allowable Class B temperature rise in both stator and rotor at full load.

Axial ventilation, by permitting more pressure drop in the air-flow circuit, reduced to half the air-to-water cooler weight. Also, because stator air ducts were no longer necessary, a shorter, more compact machine was possible. Used on the 500-kw generator was a flatplate bearing bracket with the sleeve bearing almost entirely within the wound stator. This resulted in an overall reduction in volume of 43 percent.

Repowering Ore Carrier

An innovation for Great Lakes service was a turbine-gear propulsion unit in-

stalled on the *Homer D. Williams*, a 600-foot ore carrier of the Pittsburgh Steamship Company. Installed as a part of a repowering program, the single-casing turbine is rated 3000 shaft horsepower at 8000 rpm and drives a propeller rated at 110 rpm. New machinery for the ship, built in 1917 with a triple-expansion reciprocating steam engine, increased its speed nearly 2 mph.

Submarine-propulsion Control

An improved submarine-propulsion control utilizes motor-operated switches that automatically control the main electric propulsion motors and generators. Extensive rearrangement produced a more compact and simpler control.

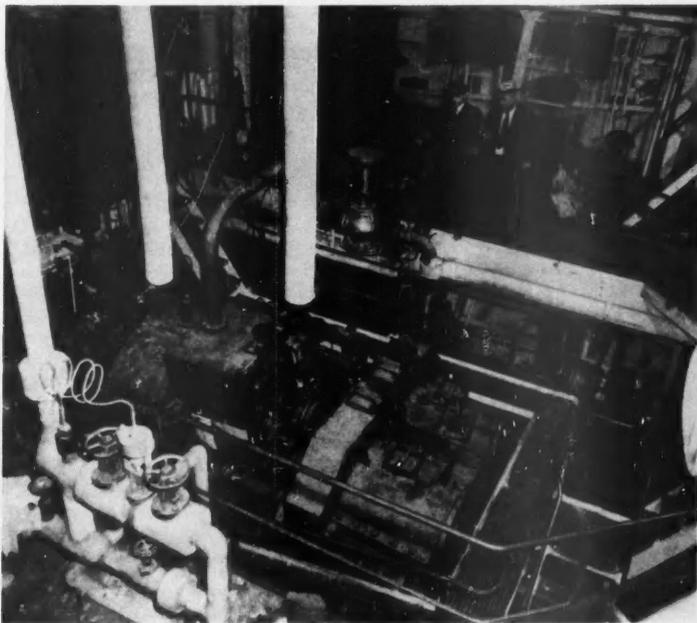
Electric Helmsman

Ships can now be steered from various strategic positions aboard by means of an "electric helmsman," a portable remote-control station for medium-size

naval vessels. Selsyn signals from the station are magnetically amplified to supply power to the motors that move the stroking mechanism of the ship's steering gear. Increased flexibility is provided by the portable steering station, in addition to its use in emergency and "close-in" operations.

Fire-control Switchboards

Over the years, fire-control switchboards were improved by decreased size, greater accessibility, and increased ability in handling more complex circuits. However, manual switching was slow, and there was always the possibility of error. In 1951, new control switchboards overcame these difficulties by using motor-driven switches remotely controlled from master stations. Pressing one button causes simultaneous or sequential operation of every switch required for the desired setup; the entire operation is completed in seconds.



SINGLE-CYLINDER geared-turbine propulsion unit on the Great Lakes ore carrier *Homer D. Williams* replaced a reciprocating steam engine, thereby increasing its speed



ELECTRIC HELMSMAN steers ship by remote control from various locations



TEN GAS-TURBINE locomotives rated 4500 hp were ordered by the Union Pacific Railroad for heavy-duty freight service

Rail

More than 100,000 miles were racked up by the first gas-turbine electric locomotive as it completed its trial runs early in 1951. Ten similar 4500-hp units were ordered by the Union Pacific Railroad for delivery in 1952. All will operate in road-freight service, thus giving the railroad world the first opportunity to observe the performance of this new type of motive power beside conventional steam and diesel-electric locomotives.

Diesel-electric Locomotives

Production of Alco-GE locomotives rose to a new high during the year and, in spite of shortages, more diesel-electric road locomotives were produced than in any year in the joint companies' history. Such production has helped the

American railroads achieve more than 50 percent dieselization of all services.

As a further step in locomotive progress, the Alco-GE 1600-hp six-motor road switcher was developed and the first units were delivered. An adaptation of the standard Alco-GE four-motor switcher, it is particularly suited for heavy-duty drag-and-transfer service.

Electric Locomotives

Two new a-c freight-locomotive units operating from an 11,000-volt single-phase 25-cycle overhead wire are now under test on the heavy mountain grades of the Great Northern Railway. They are powered by axle-hung single-phase commutator motors and feature dynamic braking—the first locomotives with single-phase a-c commutator motors on

American railroads to make use of this method of braking.

Each unit has two 2-axle swivel trucks, weighs 120 tons, and carries all weight on drivers. The continuous rating is 2500 hp; as much as 5000 hp can be developed for a short time.

Other Developments

Special auxiliary generators for high-frequency (80 to 125 cycles) power are used on both the gas-turbine and a-c freight locomotives. These permit the use of small lightweight high-frequency induction motors to drive the auxiliaries.

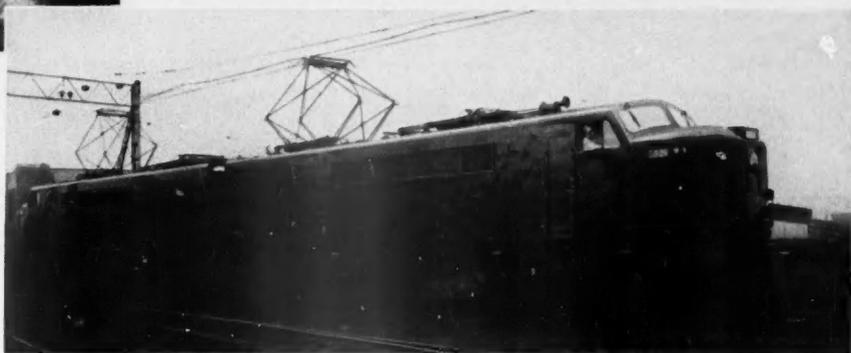
Pilot installations of diesel-driven undercar power plants continued to pile up operating hours. Outstanding among these was General Electric's



ALCO-GE diesel-electric-locomotive production reached a new high in 1951—more road locomotives were produced than any year in the joint companies' history



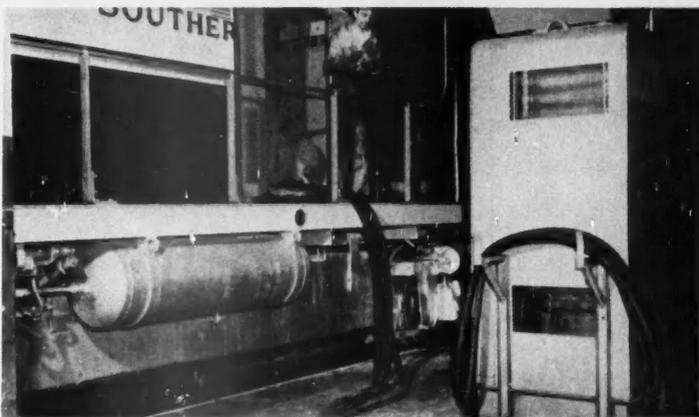
SIX-MOTOR Alco-GE road switcher for heavy-duty drag-and-transfer service



A-C FREIGHT LOCOMOTIVE develops 2500 hp continuously; 5000 hp for short time

"More Power to America Special" industrial exhibit train that completed a successful 16-month 28,411-mile nationwide tour in 1951. The cars from this train will be used by the Rock Island Lines for regular passenger service. The U. S. Army ordered 126 units for delivery in 1952.

Railroad facilities turned more and more to electric equipment to help move goods and people efficiently and economically. Unit rectifier substations replaced synchronous converters as d-c power supply for cranes and machine tools in several shops in 1951. Snowmelters were installed at an increasing rate to help the railroads maintain "fair weather" schedules despite winter sleet and snow; yard floodlighting expedited handling of freight.



LOADING RESISTOR speeds shop testing of diesel-electric power plants

Aviation

In February the J-73 turbojet engine passed its 50-hour flight-qualification test for the U.S. Air Force. Although the same size as production J-47 engines, it produces a much greater amount of thrust at a lower rate of fuel consumption.

During the year a more powerful design of the battle-proved J-47, the leading production jet engine for Air Force planes, was well established in production. This design has a "hot nose"; heated air is fed to the air inlet and melts any ice crystals that form.

Thrust augmentation by water-alcohol injection was established as a routine operation on some production models of the J-47, and a new engine equipped with a reheat burner, the J-47-17, was put into production for the North

American F-86D. Operating time between overhauls on the J-47 was appreciably increased, and a substantial reduction in the use of strategic materials was accomplished.

In 1951, the first flight of a transport with American turbojet engines was made by the Chase XC-123A, powered by J-47 engines.

Atom-powered Engine

Disclosure that General Electric was engaged in the further development of an atom-powered engine for aircraft was made in 1951. Engineers pictured a plane in which fuel consumption would be measured in pounds per day rather than thousands of pounds per hour. Some of the far-reaching implications are an airplane that could stay aloft for

many days; fly entirely around the world at local midnight, accomplishing the entire circuit under cover of darkness; and fly at maximum speed and at any desired altitude for all of its mission.

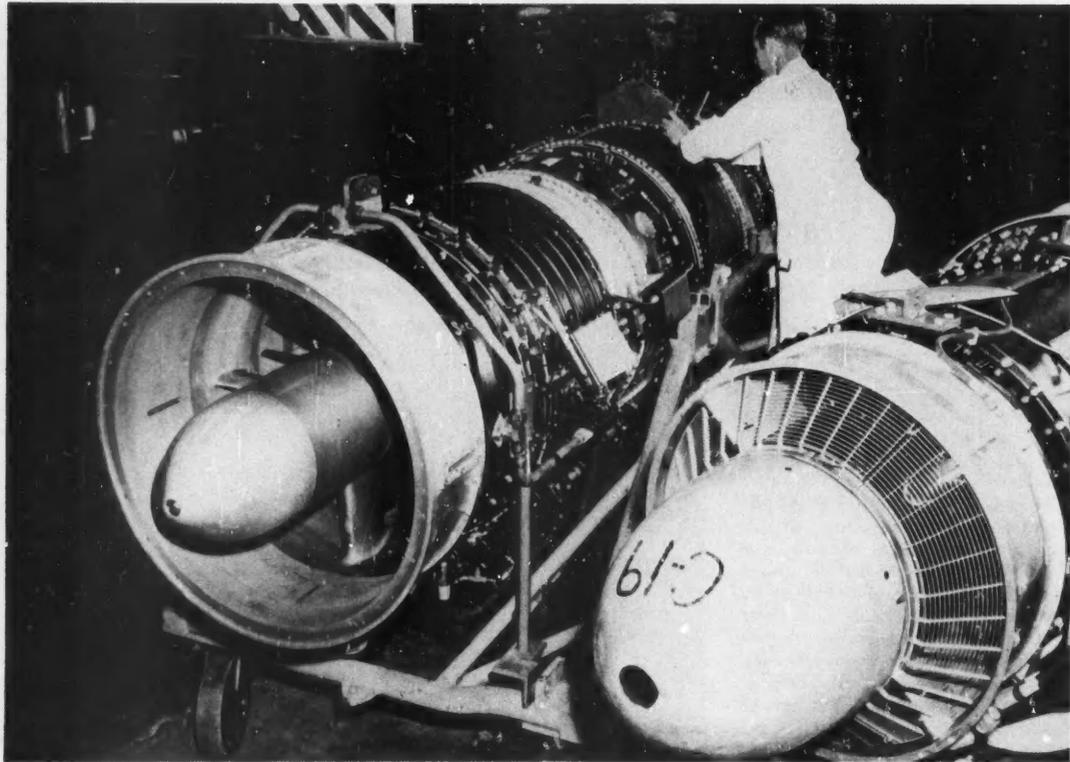
Turbosuperchargers

During the year BH-4 turbosuperchargers accumulated more than one million hours of commercial air line service on Boeing *Stratocruisers*. The average over-all life was increased to between 600 and 800 hours.

Wind Tunnels

Wind tunnels now being built for the study of supersonic speeds require motor drives of unprecedented size. One tunnel at the Lewis Laboratory of NACA, Cleveland, Ohio, will be equipped with

MORE POWER is produced by the new J-73 turbojet engine (left) than the same size production J-47 turbojet engine (right)



two drives—150,000 and 100,000 hp—making it the most powerful tunnel in the world. Another tunnel will use a 180,000-hp drive that consists of four 45,000-hp wound-rotor motors coupled in tandem to drive axial-flow compressors that generate air flow alternately in two adjoining tunnels.

Hydraulic Valves

For the control of hydraulic actuators, a new type of electrically operated hydraulic valve was developed that gives more positive control and improved operation with a minimum of control power and weight. Operation of the first valve by solenoids upsets the balance of a hydraulic "bridge". In the automatic balancing of the hydraulic bridge by movement of the second valve, full and rapid control of the oil flow to the actuator is achieved.

Aircraft Generators

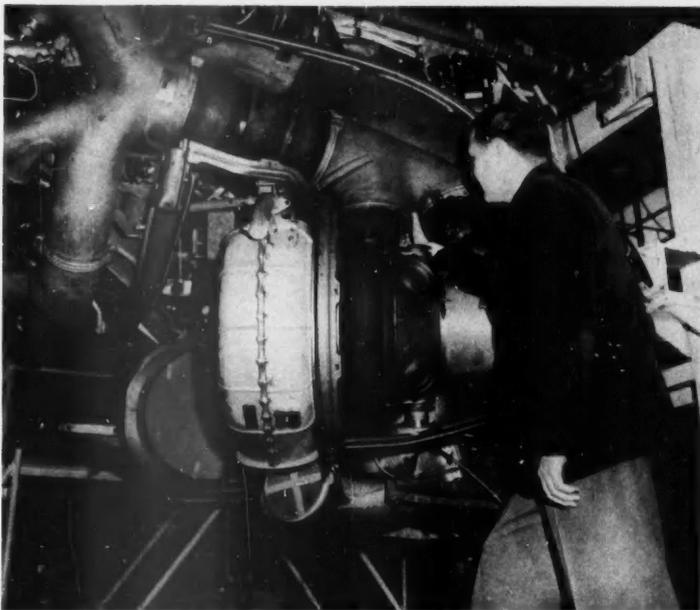
Early in 1951 a new a-c generator was designed in record time for use on one of the first all-a-c fighter planes, Lockheed's F-94C. Early shipment was quite an achievement since there were about 250 component parts in the design, and practically all were new. The generator is considerably advanced in design because it is more compact, lighter, and more stable than previous designs, and has a very good wave form necessary in the operation of aircraft electronic equipment.

A quick-attach-detach-mounting device developed during 1951 allows replacement or inspection of aircraft generators in five to 10 minutes. The new device consists of an adapter bolted to the engine pad; the generator is then attached by a bayonet arrangement locked with a single, easily accessible screw.

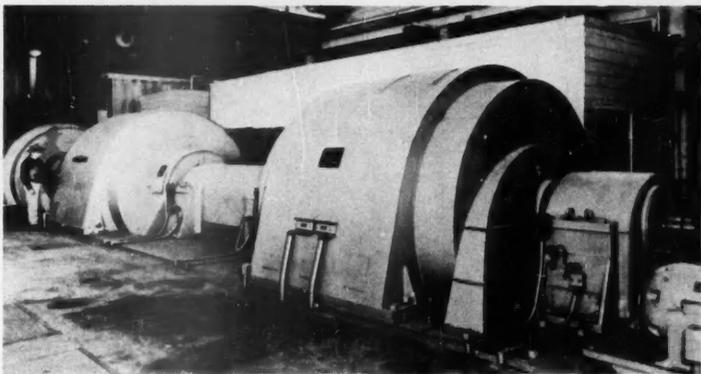
A new type of hydraulic transmission, making use of a ball-type pump and motor, was developed to drive 400-cycle generators. An output of 6000 rpm is maintained with the input speed varying over a 3-to-1 range.

Ignition Systems

To reduce insulation problems in ignition systems for jet engines, the so-called "opposite" polarity system was developed and is now used on the J-47. In contrast to the usual ignition system, in which the spark occurs between a high-voltage electrode and ground, the "opposite" polarity system uses two electrodes, one at a potential *above* ground and the other at an equal po-



TURBOSUPERCHARGERS, such as this one on a test stand, accumulated more than one million hours of commercial air line service on Boeing Stratocruisers



WIND TUNNELS require tremendous drives—from this 81,000-hp unit to the world's largest that will be rated 250,000 hp; 300,000 hp for one hour

tential *below* ground. Insulation between each electrode and ground, therefore, is necessary for only one-half the voltage between electrodes. Operating from a 28-volt d-c source, this new system makes possible engine restarts at much higher altitudes. The ignition coils, filled with a gas under pressure to provide maximum insulation with minimum weight, are capable of withstanding temperatures in excess of 300 F.

Aircraft Amplifiers

Plug-in amplifiers with subminiature components and etched wiring were developed for aircraft-fire-control computers. Assembling the components in hermetically sealed cases filled with potting compound gave exceptional resistance to shock, vibration, and moisture. Also, magnetic amplifiers were developed to operate over a wide range of conditions.

Testing

Seven special motors rated 50/75 hp, 700/2800 rpm, 230 volt were designed to test aircraft alternators on a specified duty cycle. Special features of the motor design include shrink-ring commutators, fluted shaft, special high-speed armature-coil construction, and banding for integrally mounted motor-driven blower.

An unusual co-ordinated control and dynamometer application was built during 1951 to test helicopter gears. The equipment was arranged to take any portion of the total airplane transmission output on either of two large inductor dynamometers. The dynamometers were so designed with special weighing equipment and remote-located head that the entire transmission output, and the amount of power absorbed by each dynamometer, can be read on the single remote head or directly at each of the individual dynamometers.

Guided Missiles

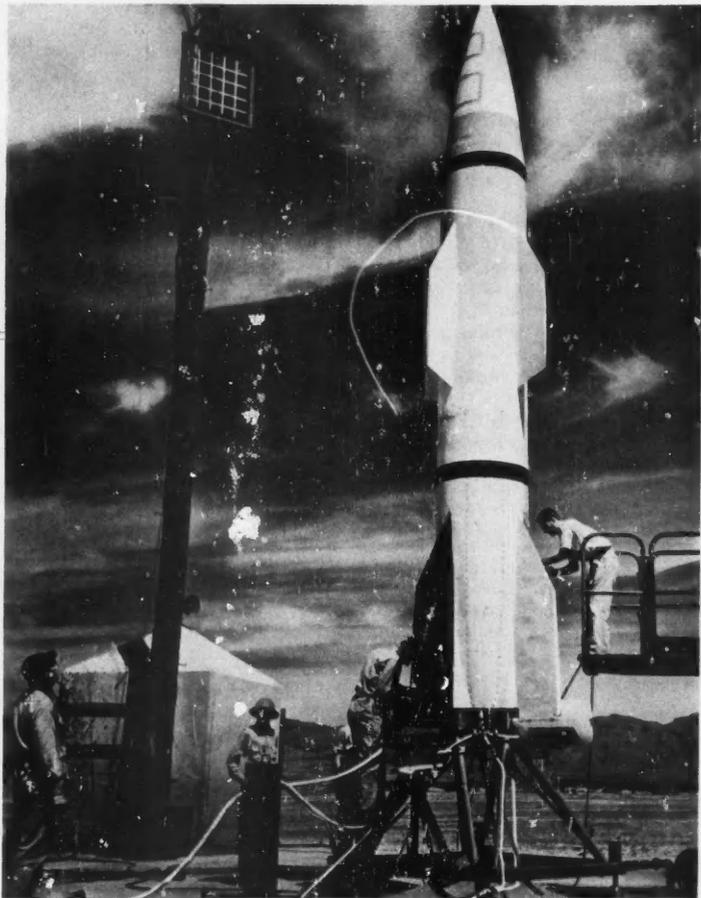
Early in 1951 the last of an initial series of General Electric designed missiles was launched at the White Sands Proving Ground. The information obtained from these tests will make it possible to achieve goals established by the military in regard to accuracy, range, and payload necessary for a tactical missile.

At the present time the Malta test station facilities near Schenectady are being expanded to include a static firing test stand. It will be possible to test missile prototypes and to completely check out the propulsion, guidance, and flight-control systems, except for the effects of altitude and velocities that are actually reached in flight.

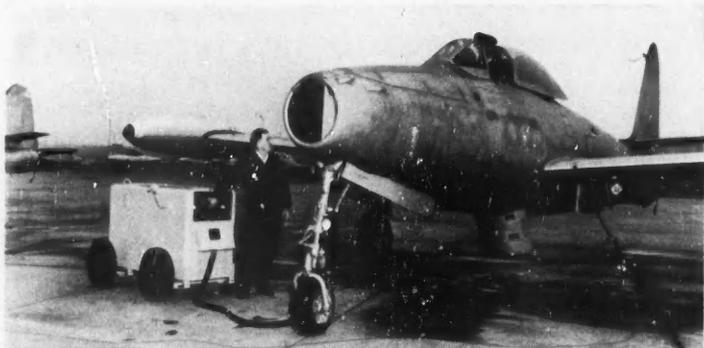
In addition, General Electric's participation in the assembly and firing of German V-2 rockets was successfully completed in July after more than 65 rockets had been launched.

Ground Power Plants

By giving special attention to effective ventilation and other engineering details, it was possible to develop a reliable long-life ground power plant that compares favorably in size and weight with shorter-lived equipments that use aircraft components. The inherent current-limiting characteristics and heavy-load capacity of the generator design eliminates the complicated current-limiting and paralleling control required in old-style machines.



HERMES A-1 MISSILE on the firing stand at the White Sands Proving Ground. This rocket was one of a series launched to gain valuable data for future designs



GROUND POWER PLANT provides reliable power; has capacity for heavy loads

Electromedical

For the first time in medical history a cancer-treatment machine was developed to utilize the high-energy radiation of Cobalt 60 in a manner similar to that of x rays—that is, at sufficient distance from the patient to permit treatment of sizable areas, to treat deep or otherwise inaccessible cancers, and to reduce the need for “planting” radioactive cobalt surgically in the tissues, with consequent danger of infection.

The unit, developed by the X-Ray Department of General Electric, emits a monochromatic beam equivalent clinically to about 2 million electron-volt x rays; its output is equal to nearly 26 million dollars worth of radium. The operating system makes possible treatment by remote control, limits the radiation to the patient, and automatically returns the isotope to a safe position in the event of power failure.

After extensive testing and biological studies at the Oak Ridge Institute of Nuclear Studies, the unit will be reinstalled at the M. D. Anderson Hospital for Cancer Research, Houston, Texas. The Atomic Energy Commission and Damon Runyon Memorial Fund for Cancer Research have also contributed toward the project.

X Ray for the Military

One of the largest orders ever received for x-ray equipment was placed when the armed services contracted for 376 high-speed military-type diagnostic x-ray units, together with 549 x-ray tubes. The engineering work on this advanced design required extensive research and development over a period of three years. Numerous meetings with military experts occurred to develop the specifications for meeting the severe service requirements involved.

The unit, whose weight is one-third that of similar conventional machines, was standardized for use by the medical services of the U.S. Army and Air Force, and the Medical Department of the U.S. Navy. Convenient wooden carrying cases, specially designed for the purpose, are used to transport the standardized components.

Use of a special gas at atmospheric pressure, instead of oil, in the trans-



HIGH-ENERGY RADIATION of Cobalt 60—another weapon in the fight against cancer

former simplifies the handling, storage, and transportation of x-ray equipment under both arctic and tropical temperatures, and high altitudes. Conventional oil-insulated designs weigh five times as much as the new transformer.

Another important contribution is a current-rectifying tube that will withstand a shock five times greater than previous tubes.

Finer Stereoscopy

Fusion of vision is almost instantaneous with a new lightweight portable stereoscope that outperforms previous units. Occupying only one square foot of space and weighing only 4 pounds, it is portable and can be easily carried. Prisms are not used, thus eliminating the necessity of setting-up, hand adjustments, or manipulation before fusion.



Electronics

Major incidents in 1951 related significantly to the field of color television. First, the Supreme Court upheld FCC approval of the field-sequential system as standard for commercial broadcasting in color. Also, the industry set up, through the National Television System Committee (NTSC), working standards for a compatible system (a color system that can also be received on black-and-white sets) of simultaneous type. This system resulted from contributions from several companies' laboratories and field experiences.

General Electric activities included all major fields of color television: the development of a source of color signals in the form of a flying-spot scanner for transparencies, a color camera for live pick-up, studio and monitoring apparatus, and receivers. Operating on Channel 2, a 5-kw transmitter radiated signals from Electronics Park, Syracuse, and data collected during field tests helped in establishing NTSC standards.

The implementation of the "frequency-interlace color-television system," begun in 1950, was carried out and was followed by additional inventions and systems, notably the "alternating-highs system" and the "alternating-lows system." The Company's independent efforts culminated in a demonstration of these three systems before the Ad Hoc Committee of NTSC during February.

This Committee reported its findings in April and recommended a broad framework of standards for a compatible system and proposed industry-wide field testing, with a view toward having NTSC accumulate and publish information as it became available. General Electric directed its efforts toward the development of a system characterized by the use of a single-color subcarrier frequency.

The present system produces one brightness and two chromaticity signals by transforming and replacing the red, green, and blue signals received from the camera. The brightness signal, transmitted on the main carrier, furnishes the compatible black-and-white picture.

The other two signals modulate a chromaticity subcarrier in quadrature with each other.

A demonstration before Panel 13 of NTSC in August showed effects obtained by operating under such conditions as double- or single-sideband transmissions of chromaticity information, effects with and without "gamma" correction, effects with and without overlap between brightness and chromaticity side bands, effects of amplitude changes of the chromaticity subcarrier, influence of random noise on the system, effects of vestigial-sideband transmissions with color-phase alternation for chromaticity information, and compatibility aspects. A standard VHF transmitter, modulated by these signals, transmitted the color pictures, and compatible pictures were picked up on home-type receivers.

Extensive analyses disclosed limitations and guided the general developmental program. The work underway in the immediate future will entail continued analyses and testing attendant to the evolution of final standards. New and improved television components—cameras, tricolor picture tubes, optical filters, and circuits—are under development.

Prototype receivers built have sufficiently flexible circuitry to permit a wide variety of transmission standards to be employed and studied. Including the picture tube and power rectifiers, these receivers use 48 electronic tubes. Recent developments point to considerable simplification and a reduction in the number of tubes.

UHF TV Receivers

The proposed 70 additional television channels in the ultrahigh-frequency spectrum from 470 to 890 megacycles comprise a little-used part of the radio spectrum; hence considerable engineering and research work has been necessary to determine acceptability for commercial television.

In June, several radio manufacturers staged a demonstration of receivers and translators for the benefit of the FCC, and it was shown that a medium-power

transmitter gave very acceptable service up to 20 miles.

The translator demonstrated by General Electric provides continuous tuning over the UHF band; self-contained and including its own power supply, it is designed for use with any standard-band receiver.

Television Transmitters

There's an entirely new approach to transmitters in the UHF band. Low-power circuits using conventional tubes in specially designed cavities generate the fundamental signal, and a velocity-modulated tube, the klystron, amplifies it nearly 100 times in a single stage. This tube's vacuum envelope contains the resonant circuits, as well as the electron source and coupling—it is essentially a self-contained amplifier. With the highest known television power so far achieved at these frequencies, it represents a major advance.

Television-broadcast Antenna

A new antenna, developed to permit maximum utilization of UHF power, consists basically of a helical rod uniformly spaced from, and coiled about, a vertical mast. Relatively unaffected by rain and ice, and noncritical in adjustment, this antenna, in four-bay form, raises by 20 times the effectiveness of the power generated at the transmitter; energy is concentrated in a disc horizontally where it is effective for exciting television receivers rather than being wasted at high angles.

Studio Equipment

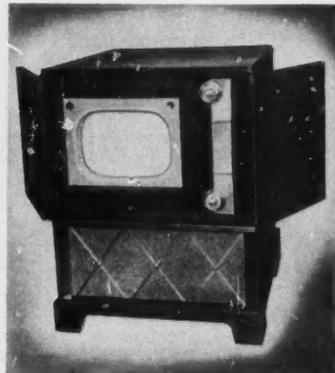
Picture-generating equipment was modernized, thus achieving manufacturing economies, improved performance, and a high degree of standardization. The studio camera has improved cooling, accessibility, operating smoothness, picture quality, and interchangeability. A completely new 16-mm TV Synchro-Lite* projector, with base cabinet housing circuits and control panel, features from 200 to as many as 600 hours flash-lamp life, automatic "slav-

*Reg. Trade-mark of G.E. Co.

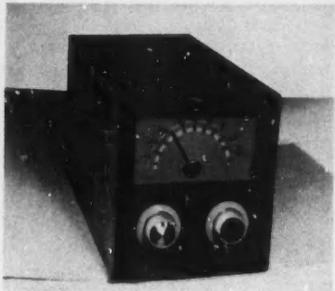
◀ FLYING-SPOT SCANNER is the source for the color picture in a developmental color TV system



KLYSTRON TUBE—heart of the 5-kw UHF television transmitter. General Electric engineers are investigating possible military applications of the new tube



COLOR RECEIVER has flexible circuits for study of various transmission standards



UHF TRANSLATOR provides continuous tuning over the entire proposed band

ing" of projector motor to the TV synchronizing system, high-quality audio, plus a remarkable projector head. This head provides exceptional dynamic resolution, quiet operation, and long life.

The sync lock, now in manufacture, controls with exceptional success a local TV system from a remotely generated signal when used with the G-E stabilizing amplifier and sync generator.

Mobile Communication Equipment

With the proper tone-receiving device attached, FM receivers will respond only to calls preceded by a coded tone; that is, the normal radio party-line system can be made a private- or subgroup-line system. Oberlin, Ohio, for example, has added tone-receiving devices to its FM receivers issued to all volunteer firemen. Only calls that are preceded by the proper tone can come through.

For similar applications and for many

others in civil defense systems, a new low-cost compact receiver is being produced. This unit, the Civil Defender, can be used to actuate a horn, siren, lights, and other equipment.

The Onondaga Civil Defense Plan (Onondaga County, NY) involves the equipping of a large trailer with racks of transmitting and receiving equipment. Housing complete communication facilities, this vehicle enables operators to coordinate movement of radio-equipped vehicles of 16 services in the area. Control of such services as police and fire may be taken over by the trailer if a bomb attack knocks out the regular transmitting facilities.

Germanium Developments

Each month about 200,000 germanium diodes are produced. Tens of thousands have gone into television sets but more have found their way into military and commercial devices.

In the application of recent discoveries, it is necessary that all grain boundaries be avoided and that maximum uniformity of the characteristics be obtained throughout an appreciable mass. To permit factory production, it was imperative that means for producing single crystals of pure germanium be developed. Equipment now under construction will permit production of single crystals on a production basis.

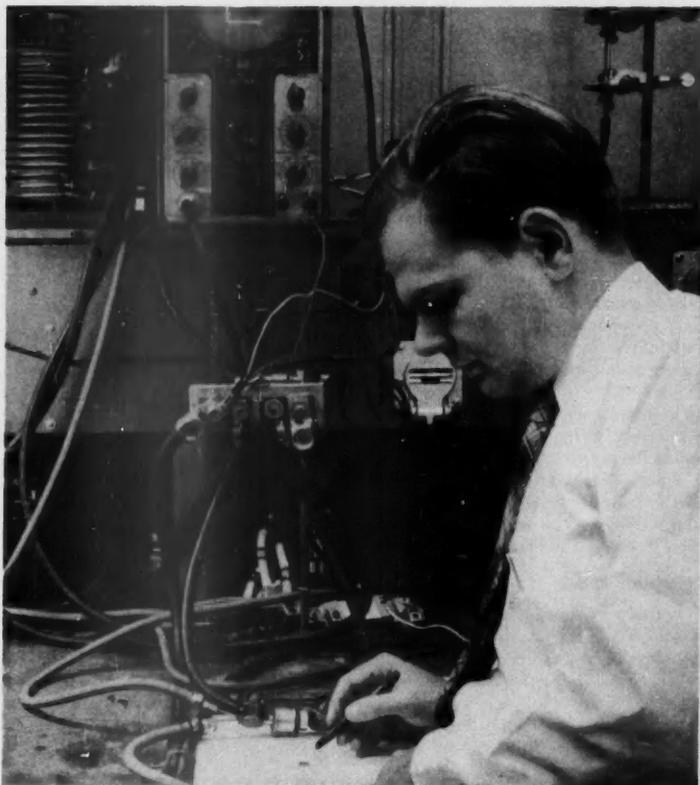
During the year a diffused type of germanium diode suitable for use at current levels up to 0.5 amp was developed; this device is now in pilot-line production. In an effort to develop a unit capable of rectifying much higher currents, units have been produced that will rectify up to 600 amp peak, with peak inverse voltages about 100 volts.

The Transistor

The transistor is a small specimen of suitably treated germanium with three



GERMANIUM PURIFICATION process (above) recovers 85 percent of the material lost in the original processing. The process produces material of equal purity with that commercially available and helps extend the supply of this important natural resource



HIGH-CURRENT DIODE WAFER, shown as a tiny rectangle (upper right), is similar to the one enclosed in a capsule that gives the E-I characteristic on the cathode-ray oscilloscope



POTTED TRANSISTOR of flea size (right). The transistor is a small specimen of suitably treated germanium—a device that stands in good position to revolutionize present-day techniques

electric contacts. Roughly, it is similar to the triode electronic tube in performance and application. Requiring no filament power, it is endowed with indefinite "life." It is extremely tiny—about the size of a match head. It needs little d-c voltage supply—approximately 5 volts for many applications. A device of this kind stands in good position to revolutionize present-day techniques.

Diffusion techniques for large-area diodes have been extended to large-area diffusion-type transistors. Unlike older point-contact transistors, these new units are completely free of short-circuit instability, have a low-noise level, higher gain, and a wider range of power dissipation. Units were produced that yield power gains in the order of 40 db per stage. They provide high-voltage and high-current gain simultaneously in a single stage. Units were constructed that permit operation at 2 watts dissipation which is by no means the ultimate limit in power-handling capacity.

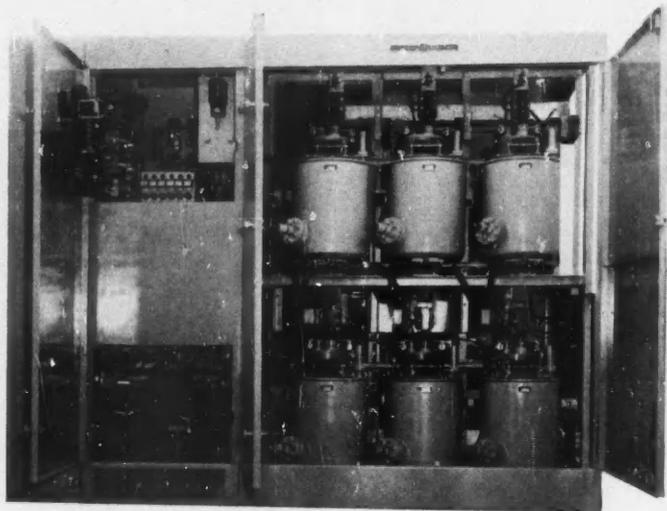
Electronic Tubes

Activity in the industrial and transmitting-tube field was directed to meeting present and future needs of the government for national defense and the requirements of television broadcasting in the UHF and VHF bands. Development was initiated on a new line of magnetrons and hydrogen thyratrons—tubes used widely in the military service.

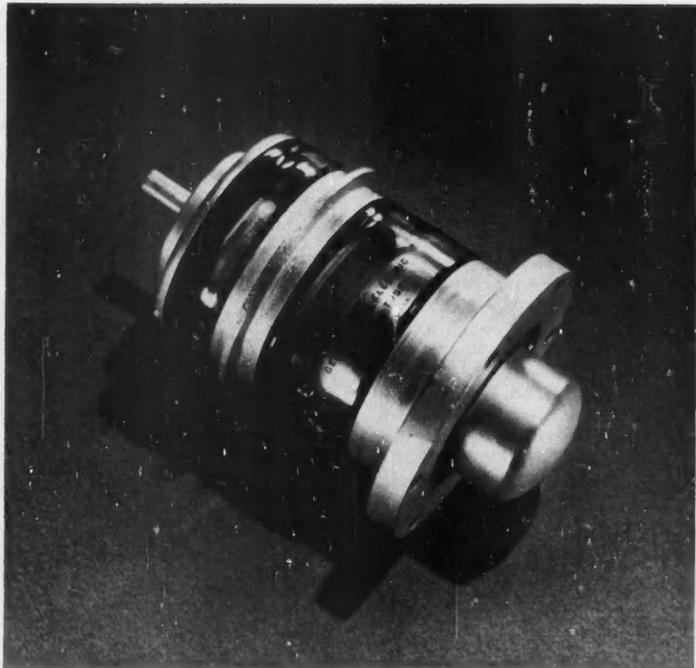
A rectifier unit with new structural and control features supplies power pulses of 3000 amp at 2500 volts for a particle accelerator at the California Institute of Technology. The unit consists of six pumpleless ignitron tanks with double grids connected for double-way operation. High-speed control is provided by new tube excitation and arc-suppression circuits.

A new high-power disc-seal tube for military equipment has a maximum rating of 1000 volts d-c on the plate, with a dissipation of 100 watts. The maximum rating applies at frequencies up to 2500 megacycles as against 500 for the older design.

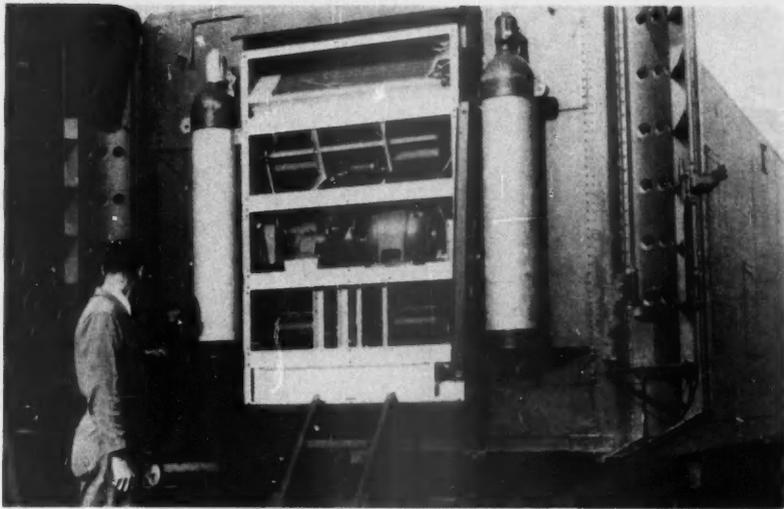
In the commercial field, new types were developed: a water-cooled tube of ring-seal construction for VHF transmitters that requires 1100 watts less filament power than its predecessor; and a low-noise twin-triode widely heralded as reducing "snow" on the television screen in weak signal areas.



PUMPLESS IGNITRON built by General Electric to supply power pulses of 3000 amp at 2500 volts for the California Institute of Technology's particle accelerator



WATER-COOLED TUBE of ring-seal construction for VHF transmitter requires 1100 watts less filament power than its predecessor, resulting in lower power costs



TRANSPORTABLE air conditioners for mobile laboratories and field medical units

Air Conditioning

To meet the highly specialized requirements of mobile laboratories, ordnance trailers, and field medical units, a low-weight high-capacity air-cooled air conditioner was developed. It consists of five "building block" components that can be assembled to suit particular installations. More than 20 units are undergoing field tests by various branches of the Department of Defense.

Heat-pump Progress

Millions of items of operating data recorded automatically on microfilm at 15 test installations in scattered areas provided an invaluable basis for improving the heat pump and developing application techniques.

Compact 3- and 5-ton package units capable of heating and cooling homes up to 3500 square feet are now being built and installed on a test-marketing basis.

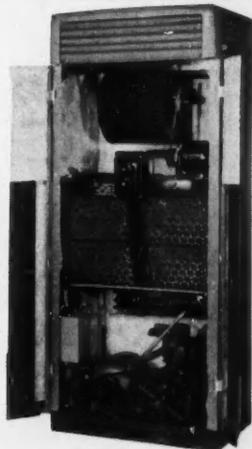
A 120-hp capacity commercial unit was successfully installed in a building of Utah Power and Light Company in Salt Lake City.

Cool Comfort

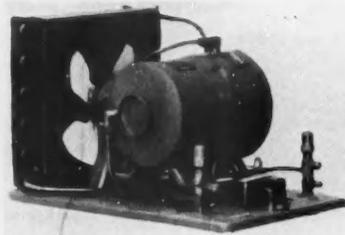
For residential use a cooling supplement to be used in combination with any G-E warm-air furnace was developed and field tested. Motorized controls for changing from winter heating to summer cooling are operated by a single changeover switch.

Early in 1951 a new Air-Wall register

was introduced to give automatic control of individual room temperature between 55 and 80 F. Automatically compensating for heat from the sun, cooking, and other influences, the register goes from open to closed with only a 5-degree temperature change.



SERVICING is simplified on new 3- and 5-ton units for commercial use. Reduction in aluminum and copper was accomplished while maintaining full-rated output



REDUCTION in size, plus a 27 percent increase in low-temperature refrigerating capacity, was obtained with the new 1/6-hp unit (right), compared with the old





SPECTRUM—one of the largest and brightest yet produced—is part of demonstration at the Lighting Mobilization Center

Lighting

The new Lighting Mobilization Center at Nela Park, Cleveland, Ohio, assembled at one focal point all the demonstrations of seeing and lighting essential to nationwide industrial mobilization activities. Its purpose is to demonstrate how light affects seeing, how light improves visibility of the seeing task, and how it creates a pleasant environment for workers.

An outstanding feature of the Center is the novel utilization of wall and ceiling areas, each of which is a separate "theater of action." Various areas are devoted to specific demonstrations, displays, and recommended fixtures for

industry, commerce, and workers' homes.

The ceiling's many-lighting-systems-in-one show that high levels of lighting in industry are both necessary and obtainable without glare and discomfort. Some 350 foot-candles of lighting are delivered from the overhead system—approximately seven times the amount of light in the average modern industrial plant.

Lighting Measurements Laboratory

The new laboratory at Nela Park is producing pretested data that make it possible to predetermine illumination

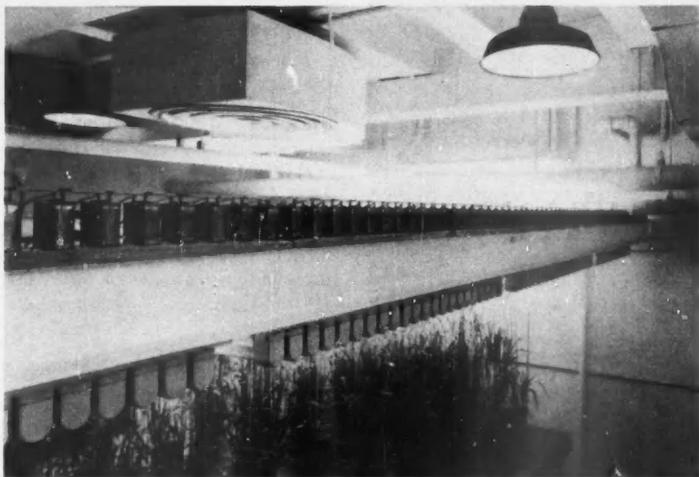
from any type of lighting system—in all sizes and proportions of rooms and a complete range of room finishes.

Test-room flexibility is so great that it is possible to obtain in hours lighting data that formerly took days to accumulate. These quick results are further aided by use of a mechanized light cell and special instruments that automatically record and translate the cell's measurements into desired information.

The dimensions of the test room can be varied from 12 to 30 feet square, and the ceiling can be raised to 16 feet. Ceiling, wall, and floor panels can be changed quickly to any pattern of color



LIGHTING MOBILIZATION CENTER of the Lighting Institute at Nela Park, Cleveland, Ohio, gives practical examples of adequate, comfortable, and pleasing lighting



UNDERGROUND GREENHOUSE of the U.S. Department of Agriculture's greenhouse at Beltsville, Md., where the fluorescent lighting system operates on 360 cycles

or reflectance; and lighting fixtures and lamps of any type can be installed and shifted about as desired.

Light Conditioning

General Electric's program to light-condition America's 40 million wired homes has spread to nearly every section of the country. Approximately 500 demonstration homes, featuring "basic lighting recipes," increased the public's light-conditioning consciousness.

Fluorescent-lighting Technique

A radical new lighting technique, a milestone in lighting progress, was adopted by the U.S. Department of Agriculture's Plant Industry Station at Beltsville, Md. The new lighting installation employs slimline fluorescent lamps operating on 360 cycles. Benefits are significant: more light is produced for the amount of current used, and tiny capacitors are substituted for conventional ballasts.

The development of a new lighting circuit and a static frequency inverter without moving parts or electronic tubes makes this advanced system possible. Early application is indicated for lighting installations in large industrial plants and commercial buildings.

Street Lighting

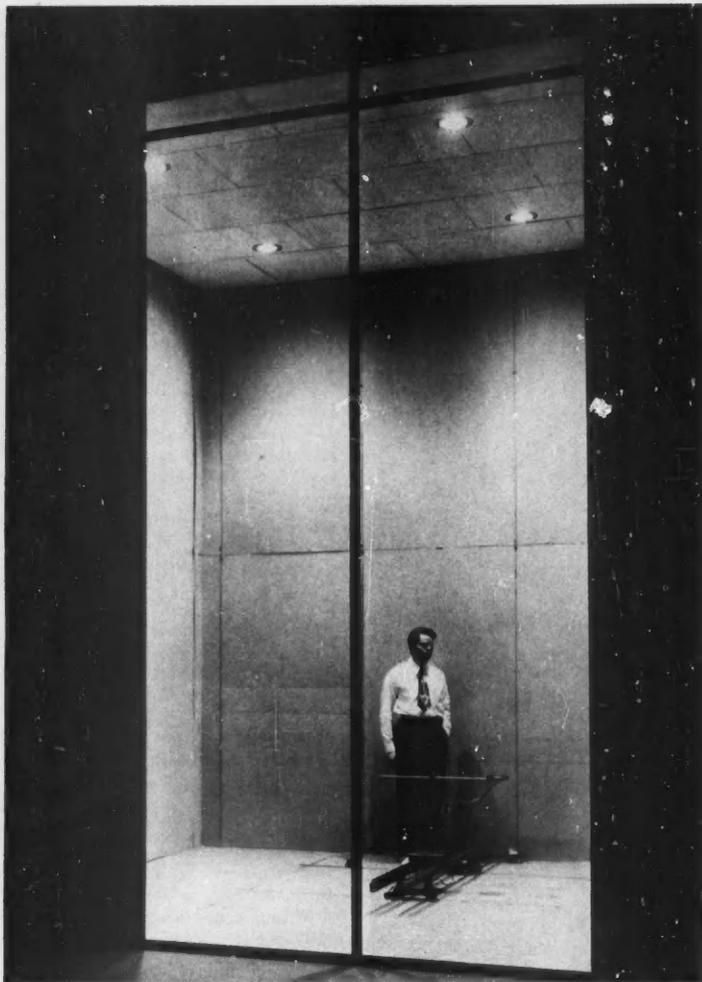
Lyndonville, Vermont, became the first community to light its entire business district with fluorescent luminaires. The installation comprises 8-foot-long units mounted 30 feet above the 60-foot-wide main street. This same type of luminaire, with its elongated fluorescent light source, has turned semidarkness to brilliance at the main entrance of GE's Schenectady Works.

Airport-runway-approach Lighting

A new regulator-controlled airport-runway-approach lighting system permits greater landing safety in "ceiling zero" conditions. This system supplements present ground-controlled approach and instrument-landing systems. The induction-voltage regulator with controls maintains any one of five separate light-intensity levels, each of which is automatically held to within one percent of the selected voltage, thus increasing lamp life and reducing glare.

Mine Lighting

Two new sealed-beam mine-locomotive headlights—the first designed by



MEASUREMENTS LABORATORY with ceiling at maximum height of 16 feet and walls moved in to make room of smallest size. A complete range of room finishes is available



FLUORESCENT LUMINAIRES give brilliant illumination under wet-roadway conditions

General Electric—have advantages over makeshifts now in general use: greater beam candlepower, longer life, more concentrated beam, more rugged construction. They are 150-watt bulbs, one operating at 32 and the other at 115 volts.

A second contribution to mining is the mine-lighting demonstrator, a box with two simulated mine entries or haulage ways, one white and the other dark. In practice, the white area is coated with rock dust or whitewash. The demonstration shows that whitening the mine is equivalent to adding 15 times more artificial light.

Bus-gate Spotlights

Five G-E spotlights beamed at electric-eye units release three gate operators for other duties at Detroit's Greyhound bus depot. These 100,000-candlepower lamps are concentrated light sources—300-watt, narrow-beam.

High-bay Lamps

Because almost no dirt collects on the bottom of the bulbs, the only place where light is emitted, two new lamps with built-in reflectors are especially desirable in foundries, welding shops, and other high-bay locations. Produced in both 500- and 750-watt sizes, the lamps employ a new bulb design that distributes light downward over working areas, and gives reasonably comfortable brightness down to 35 degrees below the horizontal.

In-flight Plane Refueling

A new type of sealed-beam lamp aids daytime and nighttime refueling of bombers in midair from Boeing KB-29 and KC-97 tankers. The lights are installed on the bottom of the tanker and supplement radioed instructions. A green center panel flashes when the planes are in proper refueling contact, and one or two of four red panels flash on when they are not—these instructing the pilot to move up, down, forward, or aft.

Igniter Circuit

A special lamp igniter circuit that gives instant hot restart was developed to operate the new compact-source lamp. A saturable-reactor ballast, with a feedback control circuit, forces the warm-up so that the lamp reaches operating temperature in the shortest possible time. These lamps, in 1-, 5-, and



TRAFFIC LIGHTS on tanker directs receiver pilots during in-flight refueling

10-kw ratings, are used for such projection applications as photolithography and searchlights.

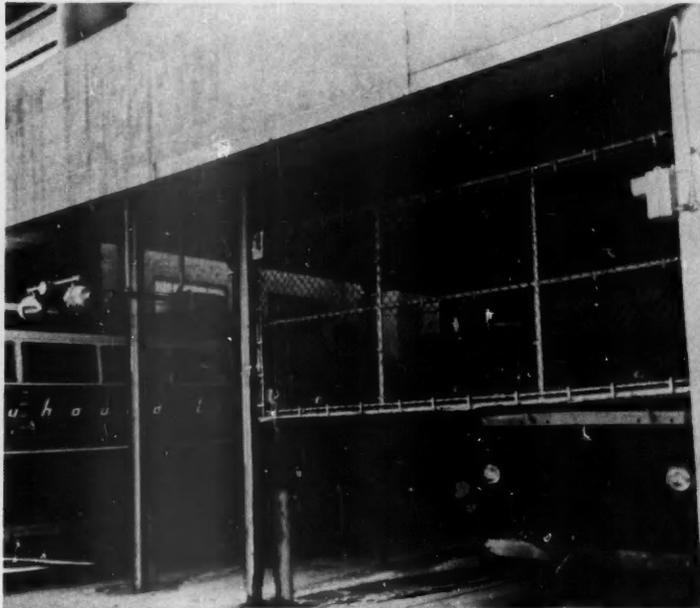
Ballasts

Most G-E ballasts are now "sound-rated" from *A* (extremely quiet) to *F* (quite audible), the rating being a characteristic of the design in question. For instance, when the surrounding noise level is high, certain types of ballasts having operating advantages but greater inherent hum can be applied without concern about noise.

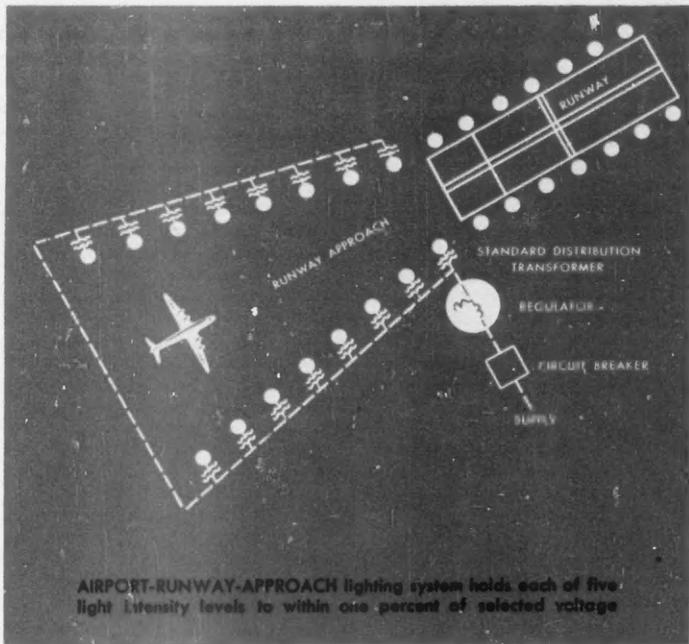
A new stabilizing circuit in the high power-factor ballast used with ultra-violet lamps for photochemical processes holds lamp watts within +2.5 percent when line voltage varies as much as +13 percent. The circuit also prevents the high-starting line currents previously experienced.

Better Light for Bus Riders

To give New York City bus riders approximately 25 foot-candles for reading, a fleet of 400 motor coaches is lighted by two rows of 42-inch slimline fluorescent lamps. Instead of the usual 60 cycles a-c, they operate on frequencies ranging from 80 to 500 cycles.



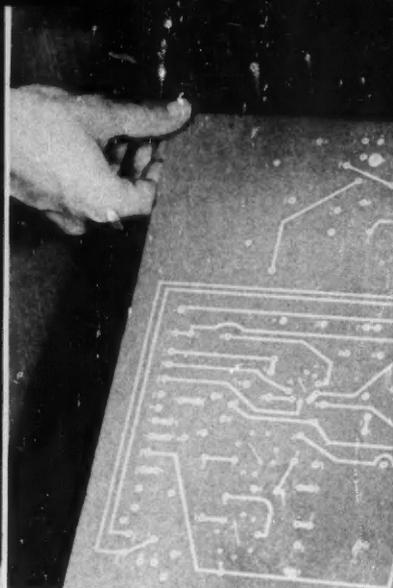
BUS-GATE SPOTLIGHTS in Detroit concentrate powerful 100,000-candlepower beam on electric eye that controls the opening and closing of two gates



AIRPORT-RUNWAY-APPROACH lighting system holds each of five light intensity levels to within one percent of selected voltage



BURNING TEST on silicone-rubber insulation produces a white nonconducting ash. Conventional rubber burns to carbon, an electrical conductor



PRINTED CIRCUITS, using laminated plastics faced on one or both sides with

Chemical and Metallurgical

During the year the rapid growth of silicone materials continued with the development of several new products and applications.

Silicone rubber, improved in physical and processing properties, gained wide acceptance. One low-temperature rubber that retains its flexibility at -110°F is used for aircraft-instrument shock mountings.

Silicone rubber, calendered into both supported and unsupported tapes, is used for insulation of cables, traction motors, generators, and other products that require flexible Class H insulation. Silicone rubber insulation on cable retains insulating value even after being burned, because of the formation of a silica rather than a carbonaceous residue.

Among the uses found for new silicone adhesives that bond silicone rubber to metal, glass, and other surfaces is the fabrication of laminated structures for printed circuits that operate over wide extremes of temperature.

Silicone fluids are also used to good advantage in the dehydrated-foods industry. Because of their "release" properties, these fluids eliminate the serious sticking of fruits and vegetables to dry

trays in which the desiccated products are heated.

High-temperature lubrication of ball bearings is possible with new silicone greases; tests showed satisfactory operation at 200°C for thousands of hours.

Protective Coatings

An altogether new concept in corrosion-resistant surface-coating materials resulted from the introduction of the coating intermediate known as R-108. As an indication of its versatility, R-108 may be formulated into highly flexible and resistant coatings for cans, drums, and other containers. And it may be prepared in such a manner that tough porcelain-like finishes result for the protection of large chemical storage tanks. Ordinary steel chemical-processing equipment, coated with finishes containing R-108, can thus be substituted in many applications for expensive and hard-to-get alloys.

A new pure-alkyd resin, known as G-E 7422, has a rapid air-set time (dust-free in five minutes in unpigmented films), high baking speed, and quick development of toughness and hardness. This vehicle, when used in primers and lacquers, has superior adhesion to metals

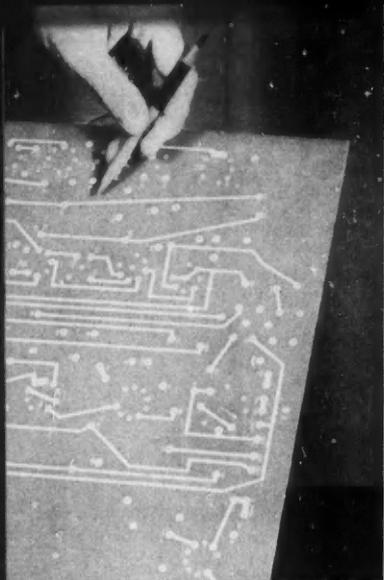
and outstanding resistance to salt spray and humidity.

Glyptal 91033, an improved vehicle for printing emulsions, proved useful in the textile field. Reports indicate that this product attains the best color value, wash resistance, and crack resistance of any known resin.

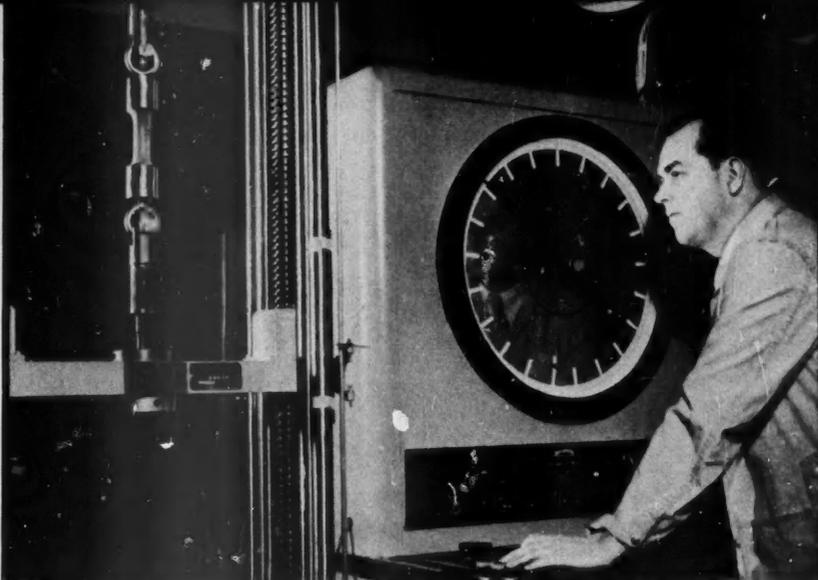
Electrical Insulation

A new clear-baking insulating varnish, G-E 9700, has exceptional through-cure characteristics, excellent bonding properties at high temperatures, and good heat-aging resistance as measured in terms of retention of flexibility.

A new wire-insulation system was developed for high-temperature applications. The only insulated wires known that meet the requirements of space factor, temperature, and dielectric properties are those insulated with the fluorocarbons—Teflon and Gercot-Teflon, for example. Because these materials do not have sufficient abrasion resistance, the application of one mil of Formvar resin over the fluorocarbons provides the answer, producing a successful wire-insulation system. Aircraft motors using this new wire have operated successfully at temperatures of



copper or aluminum foil, are finding wide use in the electrical industry



TENSILE TEST puts sample of new silicone adhesive under 900 pounds pull. Under greater tension, the rubber breaks before the bond that links it to the steel caps

200 C. Although the Formvar resin ages rapidly at this temperature, the fluoro-carbon insulation maintains its properties once the wire is assembled in the motor.

Metal-clad laminates, with paper-

phenolic cores that exhibit high insulation-resistant properties under humid conditions, were developed for use in printed circuits. Glass silicone laminates are used where such circuits are exposed to higher temperatures.

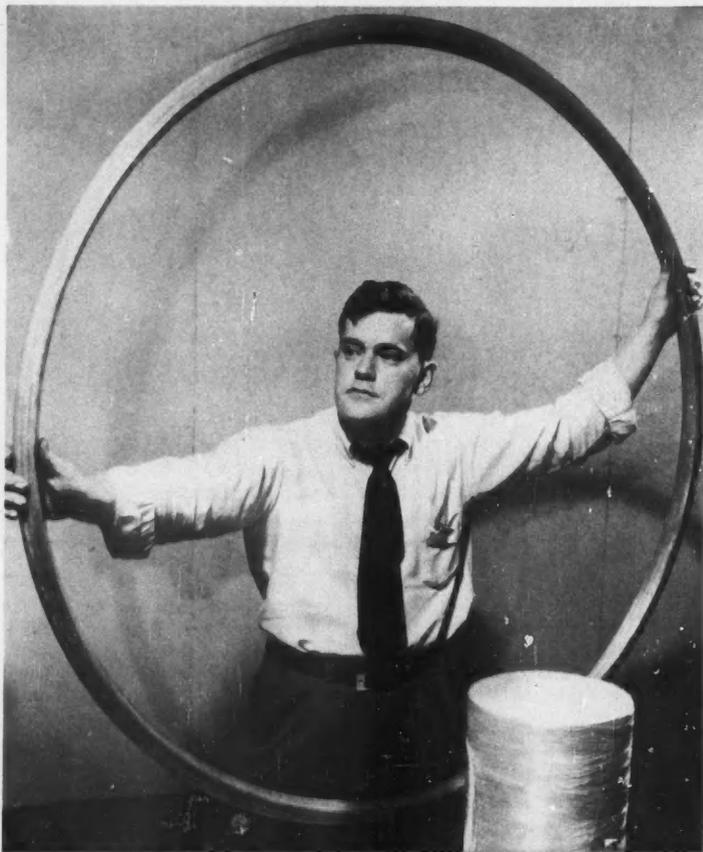
Molding Compounds and Resins

During the year General Electric's newly developed fast-cure general-purpose thermosetting molding compound 12853 showed a 15 to 25 percent reduction in cure time under actual molding

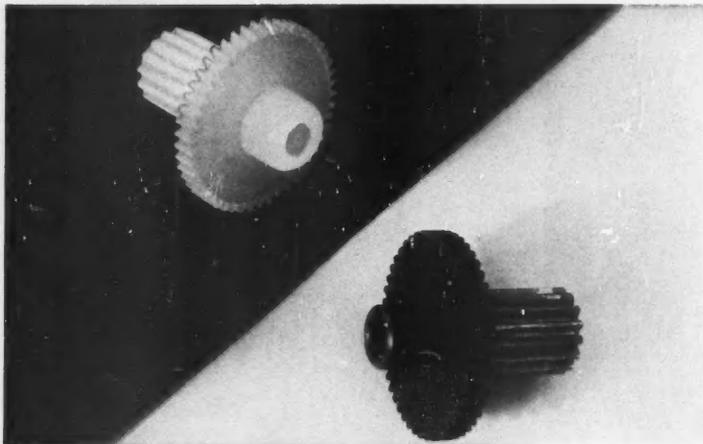
R-108 COATING INTERMEDIATE gives a corrosion-resistant surface on containers; can be substituted for scarce alloys

GLYPTAL ALKYD RESIN 7422, used in primer, resists deterioration from salt water. Popular alkyd primer is used on right panel





BINDING BAND is fabricated from glass fiber impregnated with polyester resin



NYLON GEARS reduce cost, save critical and hard-to-get metals

performance tests over a wide variety of applications.

A mineral-filled-alkyd thermosetting molding compound was developed using a special resin that offers very fast cure and excellent electrical and moisture- and heat-resistance properties together with dimensional stability. It cures in one-fourth the time of conventional phenolic molding powders, and at lower temperatures and pressures. Applications are for circuit breakers, arc chutes, and intricate parts designed to close tolerances. The compound is a dry granular powder, easily handled in fast-acting automatic presses.

A powdered-phenolic resin was developed for use as a binder with asbestos in molded brake-band linings. Field tests show that this material possesses the diverse handling properties necessary, and that it allows a lowering of friction losses at high operating temperatures.

A whole family of materials was developed for the foundry industry. This includes an improved liquid core-binder resin, a powdered-phenolic binder for the new and expanding shell-casting process, polyester sealing compounds for impregnation of porous castings, and special silicone compounds for mold release in the shell-casting process.

Laminated Products

Decorative laminated-surfacing material is now molded into kitchen-work-surface units, complete with back-splash and dripless front edge.

A new application of a plastic to provide both mechanical strength and insulation was the result of a request for generator binding bands to replace the present tape-insulated steel bands. Plastics experts found that continuous glass fiber, impregnated with a polyester resin, could be wound on a mold to produce a 4-foot ring with sufficient mechanical strength and with greatly improved insulating quality to replace the steel band.

Plastic Molding

Completely new markets for plastic moldings became possible with the installation at the Company's Decatur, Ill., plant of two new injection presses. With these presses, sections up to 1000 square inches and 13 pounds can be molded in a single operation.

Gears, bearings, retainer rings, and sleeves for various appliances and machines are now being molded from nylon.

A modular plastic-molded radio-cabinet unit was designed. Its basic component is a simple rectangular case that can be altered in appearance with a simple change of dial knobs, speaker panel, or end plate.

Cemented Chromium Carbide

Series 600 cemented chromium carbide, a new product developed by the Carbology Department of General Electric, went into production in 1951. It is superior to regular carbides in resistance to red-heat oxidation, and to the corrosive effects of acids, alkalis, salt sprays, and superheated steam. In addition, the metal is nonmagnetic, has a specific gravity somewhat less than that of steel, and an expansion coefficient closely comparable to that of steel.

Hard Surfacing

A method of hard-surfacing ferrous alloys with cemented tungsten carbide was developed during the year. First, a cemented-tungsten-carbide rod is prepared by a simplified extrusion and sintering process. Then an inert arc-welding torch puddles the sintered-carbide rod on the surface of the work piece. The resulting surface contains about 70 percent tungsten carbide, a higher concentration than provided by any commercial hard-facing welding rod on the market today. Dry-abrasive-wear tests indicate a resistance about 80 percent as good as sintered tungsten carbide and several times better than hardened steel or chilled cast iron. The hard surface layer can be made in thicknesses from $\frac{1}{16}$ to $\frac{1}{4}$ inch and can be ground in the same manner as sintered carbides.

Other Developments

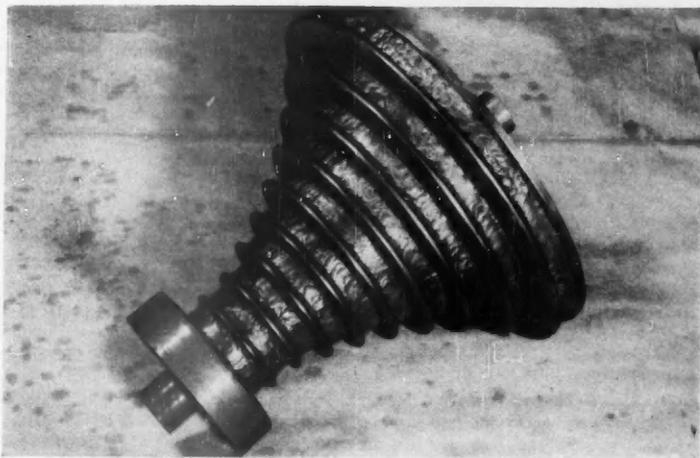
Another development in the metallurgical field is the use of a direct-reading spectrometer to determine the alloy composition of metals used to produce alnico magnets. The instrument gives a complete analysis of these eight-element alloys in less than three minutes—compared to the wet-chemistry method of several hours.

Deep-hole trepanning of gun barrels with carbide tools and high-speed drilling of cast iron with carbide-tipped tools continues to speed production processes for defense.

HARD-SURFACING with cemented-tungsten-carbide welding rod of this part used for wire-drawing will give it longer life



MODULAR RADIO CABINET can be made into eight different cabinet styles





REMOTE-CONTROL WIRING at the new Columbia, SC, fire headquarters gives one man control over a multitude of operations

... For Building Construction

Remote-control wiring, first introduced for residential use, made great strides in commercial and industrial markets. In conjunction with the new rating of 5 amp, 277 volts for the relays, it is now practical to use remote-control wiring on 480Y/277-volt distribution systems for office lighting and other applications.

An installation at the new Columbia, SC, fire department headquarters created widespread interest. Remote control is part of an intricate electric system that allows one man at the switchboard to alert all firemen over loudspeakers located throughout the station, to turn on or off every light in and outside the firehouse, open and close the eight doors, control every one of the city's 88 traffic lights, maintain a two-way radio conversation with all

apparatus, and to record all phone fire-calls coming into the station.

To aid surface mounting of remote-control relays, Monowatt Department of General Electric developed a junction box surface-wiring device that will accommodate the standard relay for operating electrical outlets in barns, garages, cabins, or any location where surface mounted devices can be used.

Safety-switch Tests

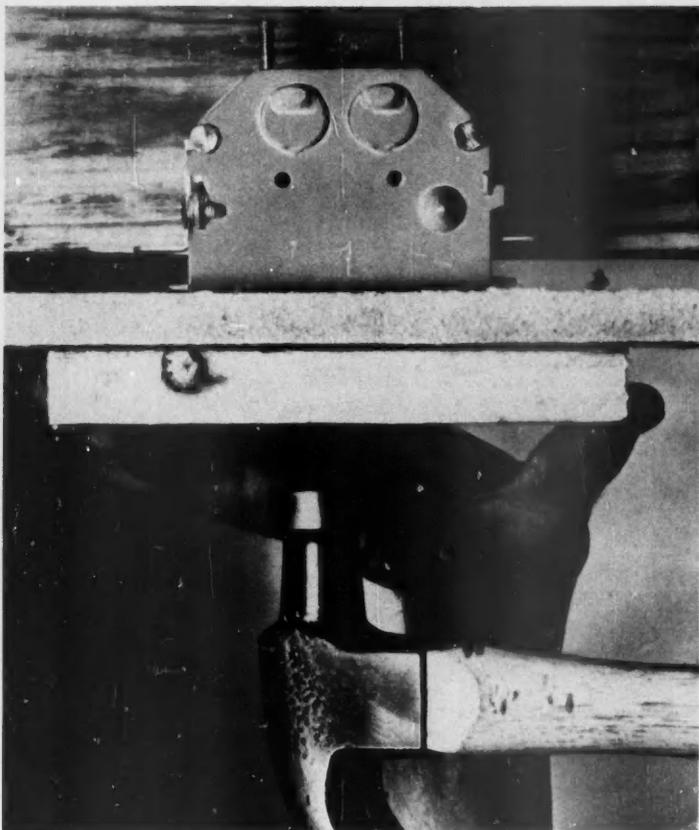
The new HCI safety switch was adapted to use the EJ-6 current-limiting fuse, followed by an exhaustive test program on the combination. In test, the combination handles short circuits at available current levels of 100,000 amp, which is considerably beyond previous safety-switch applications.

Improved Switch Boxes

Levelock switch boxes were produced with a new mounting bracket that is attached to the box by mechanical means and reinforced along its entire length so that it will resist bending when struck by a hammer. The boxes have been designed not only to withstand the usual installation treatment but also to stand up under the rough abuse encountered in the newer dry-wall type of construction.

Cord Set with Grounding Plug

An 8-foot cord set with grounding plug was developed to meet the new NEMA standard for improved grounding. It has a molded-on plug with a special ground pin to provide positive third-wire grounding. The grounding pin is an integral part of the plug and



LEVELOCK SWITCH BOXES won't come apart under rough handling

requires no secondary operation of attaching grounding lead or strip.

Other Developments

The Trumbullite load center and NLQ panelboard line using the quick-make quick-break plug-in-type circuit breaker was extended to include rain-tight enclosures and column-type panelboards.

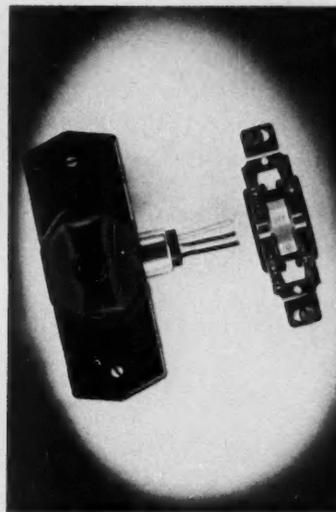
A new low-cost residential-type toggle switch was developed that has double-wipe contacts that will take a current inrush of eight times the amperage rating of the switch. Tests were made with tungsten-filament lamps on direct current.

Developed originally for interior illumination of household refrigerators, a snap-in lampholder is equally adaptable to other applications requiring a

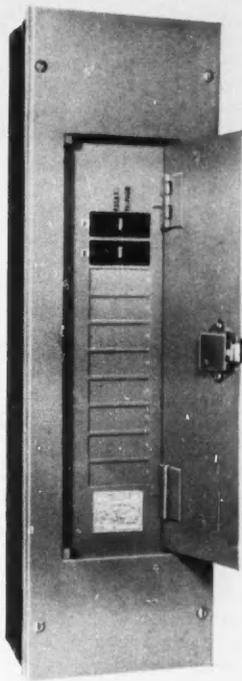
weatherproof lampholder using minimum lamp space. The socket hood is made of a special-type rubber compound designed to prevent moisture condensation on the surface, thereby eliminating electrical leakage to ground.

A twin-turret lampholder, developed for 85- and 100-watt fluorescent lamps, holds them so tightly that no safety devices are needed to keep lamps from falling out of the fixtures.

Four new utility-light cord sets were developed for use in the home: one, with 9 feet of cord, is used like a flashlight; another is attached to a telephone to light up the dial and phone stand at night; the third can be used as a pin-up night light; while the fourth, a closet light, is installed on the door jamb to turn on the light when the door is opened.



JUNCTION BOX for remote-control wiring system and new low-cost toggle switch



PANELBOARD is of narrow-column type for mounting in vertical steel columns



APPLIANCE PARK as it will look when completed at Louisville, Ky. It will be the world's largest electrical appliance plant

Appliances

Most important announcement of the appliance industry in 1951 was that General Electric had started construction of a multimillion-dollar Appliance Park just outside Louisville, Ky. When completed several years hence, the Park as proposed will be the largest electrical appliance manufacturing plant in the world. It will also be the headquarters of the division's administrative, engineering, and marketing operations.

Substitutes for Critical Materials

Because of the general situation at home and abroad, introduction of a number of new appliance designs originally planned for 1951 was postponed. A major engineering effort involved the conservation of critical materials, particularly substitutes that save copper,

nickel, aluminum, cobalt, and other metals. A rigid requirement is that all substitutions of materials must not impair quality or performance. But some sacrifices in the way of appearance, increased weight, or increased cost were accepted.

Refrigerators use copper tubing, and for many parts of the refrigerant circuits no satisfactory substitute has been found that would be sufficiently corrosion-resistant in a "wet" condition and also have adequate heat-transfer characteristics. Nevertheless, substantial savings of copper have already been made, and still further savings will be effected in designs shortly to be released for production.

Plastics and plastic-coated steel replaced brass in many appliance compo-

nents, including handles. Glass-fiber-reinforced plastic replaced aluminum in some parts; cast iron replaced die-castings; and in one valve, nylon replaced brass. The aluminum evaporator and liner of the 11-foot food freezer was replaced with porcelain-enamel steel; a new acid-resistant top-coat enamel developed within the year has greatly improved properties.

The magnetic latch for refrigerator doors was discontinued in 1951 to conserve the cobalt in the alnico magnets. Motors for wringer-type washing machines now have aluminum windings, effecting a considerable saving in copper.

New Developments

The new combination sink and under-counter dishwasher differs from prior



NEW WALL CABINETS, with accompanying underwall cabinets, provide easily reached storage space



SWIVEL-TOP features a new vacuum cleaner—virtually tip proof—which has long reach and disposable dirt bag

models in that the dishwasher fits under the drainboard and slides out to be loaded and emptied. The machine can wash and dry up to 100 pieces in 30 minutes.

A special starting-stopping switch on an improved lower-priced automatic washer permits the user to stop the machine at any time.

With a reach of over 8 feet, a new swivel-top vacuum cleaner has its motor mounted in the base and is therefore virtually tip-proof when pulled over rugs and sills. Its double-capacity dirt bag is designed to be thrown away when full. There's no dust-disturbing air blast because the exhaust system diffuses the air through a narrow slot around the cleaner's circumference.

The new-style automatic blanket dispenses with thermostats in the blanket and is equipped with a vertical easy-to-read bedside control.

Turning the triple-whip mixer's control beyond the OFF position automatically releases the beaters for easy removal. A mechanical finish on a new automatic sandwich-grill-waffle iron prevents sticking of waffles to grid.

In G-E hand irons the diameter of the heating element in the soleplate was reduced from 0.315 to 0.285 inch. This made it possible to decrease the thickness of the aluminum casting and thus to reduce the use of aluminum in the casting by 16 percent, resulting in an annual saving of 200,000 pounds. Also, there's an annual saving of 46,000 pounds of magnesium oxide. Of equal importance was the 1/4-pound saving in weight in each iron with aluminum soleplate.

Clocks

The new 1951 clocks, at the forefront of style trends, present basically new appearances. On the *Claustman*, for example, numerals and dial markings are made by newly developed heat-stamping methods using ribbon paper on the polystyrene crystal's concave inside surface.

Ivy, developed by the Telechron Department of General Electric, has twin canisters for a vine. To hold the canisters securely in place, they are slotted and the case is especially designed with two locking projections.

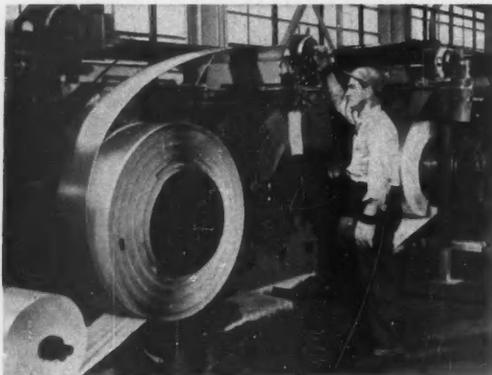


PERSONALITY alarm clock has space where hobby items can be inserted

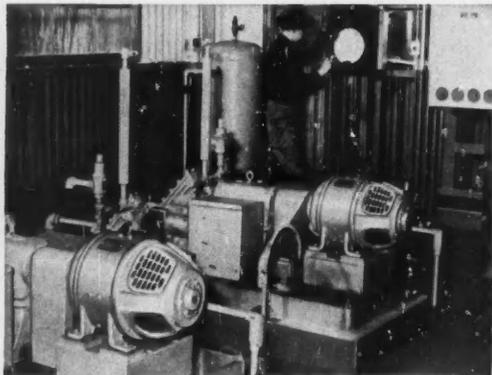
The assembly required special draft to retain the tight-locking feature and also obtain regular appearance. In addition, the mold was designed with a special cavity arrangement to permit withdrawing the case after molding.

Personality is a new alarm clock for "slip-ins" of various types of hobby and decorative displays. A special front panel, designed integral with the case, is arranged with stiffening webs to serve as supporting ribs for the slip-ins, or to provide 16 rectangular compartments for small displays.

4 WAYS TO HELP KEEP YOUR PRODUCTION ON SCHEDULE

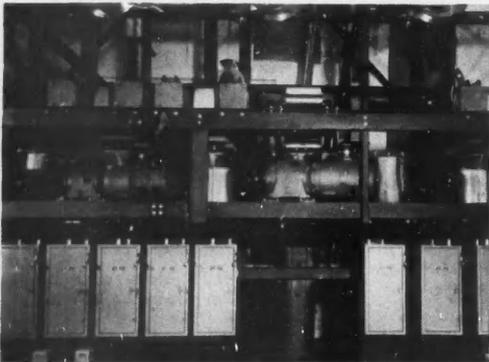


ELIMINATE MANUAL OPERATIONS. If you're winding a continuous strip and constant tension is a problem, this might be an idea you can use. The Wallingford Steel Company recently installed seven G-E Speed Variators on the winders in their strip steel annealing and pickling line. Before, a lot of time was lost in manually adjusting winder speed and tension to compensate for spool buildup. Now? It's done automatically by the Speed Variator. And they get a better-wound spool. Ask for Bulletin GEA-5335 on G-E Speed Variators.



MAKE QUALITY CONTROL AUTOMATIC. Perhaps you're finding it difficult to accurately control a chemical proportion operation. Fibreboard Products, Inc. solved this problem by putting a G-E Thy-mo-trol® Drive on a chemical pump which injects a chemical conditioner into process water as it is needed. The trick is to keep the flow of chemical accurately proportionate to the demand—no trick at all for Thy-mo-trol. Ask for Bulletin GEA-5337 on Thy-mo-trol drive.

*Reg. Trademark of General Electric Co.



GO FROM BATCH TO CONTINUOUS. To boost production, more and more companies are switching from batch to continuous operation. This accounts for the great interest in this "junior" bleaching range now being produced by the H. W. Butterworth Co. Its G-E ACA gear-motor drive helps make it flexible, efficient, and economical. Speed control is easily obtained over ranges of as high as 20:1. Ask for bulletin GEA-4883 on ACA motors.



INCREASE MACHINE SPEED to get top efficiency out of your equipment. The J. Bishop Company faced a problem of frequent breakage while drawing wire and tubing thinner than a human hair. This G-E Speed Variator, installed on a vertical bull block, reduced costly breakage to the minimum, turned a complicated process into one simple operation.

To get the bulletins mentioned above, write Section 646-16, General Electric Co., Schenectady 5, N. Y. A 26-page manual on electrical adjustable-speed drives in general is also available; ask for Bulletin GEA-5334.



Headquarters for ELECTRICAL ADJUSTABLE-SPEED DRIVES

GENERAL ELECTRIC

646-16

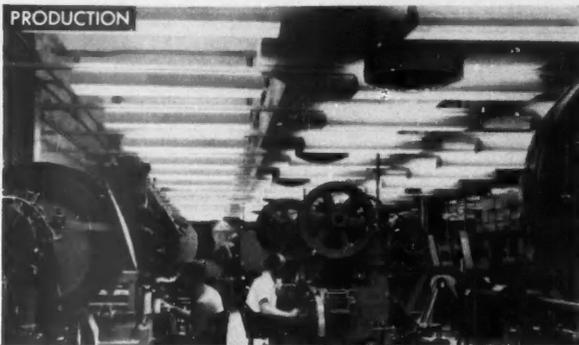
*The costliest place
to catch mistakes
is here→*

Best-lighted area in most plants today is the inspection table. But good inspection lighting can only help catch errors *after* they occur—and time and materials have already been wasted.



*The cheapest place
is here→*

By giving production workers as good light as you give inspectors, mistakes are prevented. There are fewer errors, less fatigue, fewer accidents.



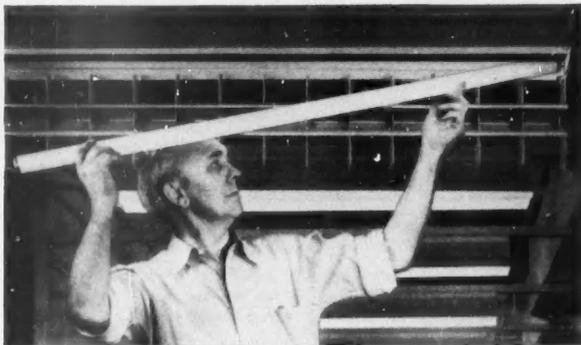
Photos courtesy Messis & Controls Corp., Attleboro, Mass.

THE BEST WAY IS WITH "5-WAY IMPROVED" GENERAL ELECTRIC FLUORESCENT LAMPS!

As a result of recent improvements made by General Electric lamp research scientists, G-E fluorescent lamps now give:

- (1) Increased efficiency (improved phosphor)
- (2) Better uniformity (improved processes)
- (3) Less end blackening (purer materials, more accurate controls)
- (4) Longer life (new materials and methods)
- (5) Better color rendition (new Deluxe White lamps show colors as they really are)

Workers see better, work better under cool fluorescent light with less glare, fewer shadows. Newest form of fluorescent is G-E slimline—up to 8' long, single pin base, instant starting.



You can put your confidence in

GENERAL  ELECTRIC



FREE BOOKLET! How to light up for better production. For your copy of "Planned Lighting for Industry," write General Electric, Department 166-GER-1, Nela Park, Cleveland 12, Ohio.



**MOTOR
STARTERS**

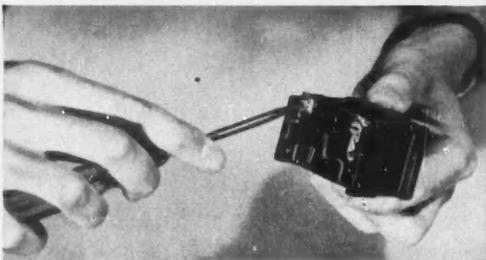
...need less

MARTIN KELLY, PLANT-



Mr. Kelly: "A big part of my job is to keep every piece of electrical equipment in the plant going—with the minimum of maintenance. That's why I want to know how a motor starter is going to perform a year, even 5 or 10 years from now. I've found that G-E starters need less upkeep than any other starter on the market today. Let me take it apart and show you why."

Martin Kelly, Plant Electrician for John R. Evans & Co., changes an overload relay on G-E combination starter quickly and easily.



Mr. Kelly: "First, the coil. It sure takes rough handling!"

1 Right you are, Mr. Kelly. We call it the "Strong-box Magnet Coil." That block of plastic keeps the windings permanently protected against dirt, moisture, and oil. And if your screwdriver slips, it can't damage the windings.



Mr. Kelly: "I've seen no sign at all that these contacts are burning or pitting."

2 That's because they have fine silver tips that outlast by far the ordinary type contact. Even where it's a "start-stop" job with dozens of operations each minute, they'll stand the gaff.

GENERAL



ELECTRIC

upkeep for 4 big reasons!

ELECTRICIAN, SHOWS WHY—WITH THE "SCREWDRIVER TEST"



Mr. Kelly: "There doesn't seem to be any wear on the moving parts."

3 That's right. The moving structure is rugged and basically simple. There's no metal-to-metal friction between magnet and coil; thus, little or no wear. And the "molded-in" lubricant in the coil keeps the magnet operating smoothly and quietly for life.



Mr. Kelly: "Overload protection means a lot; I certainly don't want any burned-out motors these days."

4 Those overload relays will give your motors all the protection they'll ever need. They are reliable and never need any attention. Heaters are in front and can easily be changed without disturbing any wiring.

MANUAL STARTERS, TOO . . .

For infrequent starting of 7½ hp or smaller motors, you can't beat a G-E manual starter for economy and dependable operation. . . Built to the same rugged specifications as the magnetic starter, it includes many of the same features for long life and easy upkeep.



Front-connected clamp-type terminals, and plenty of wiring space.

Fine silver contacts long outlast ordinary contacts

Sturdy, vibration-resistant, snap-action switch mechanism

Bimetallic overload protection with heaters readily accessible

A complete line of control accessories . . .



Push-button stations, limit switches, photo electric relays

. . . and many others can make operations more automatic, more convenient.

BUY ONE AND COMPARE! Disassemble a G-E motor starter, magnetic or manual, and inspect it. See for yourself why G-E starters last longer, cost less to install, and are easier to maintain than any starters you can buy. Your G-E representative or authorized distributor can supply many models of G-E starters in NEMA sizes 0, 1, 2, and 3 for motors up to 50 hp; anticipate your requirements and place your order early. For more information on magnetic starters, write for Bulletin GEA-5153; manual starters, Bulletin GEA-1522. Section 730-20, Apparatus Department, General Electric Company, Schenectady 5, N. Y.

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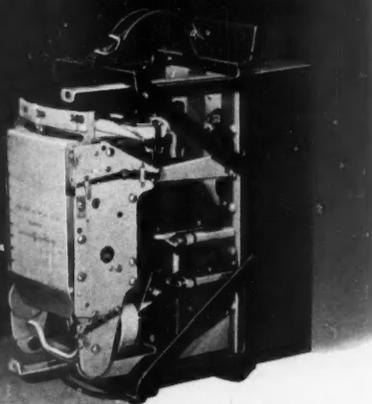
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INTERNATIONAL GENERAL ELECTRIC COMPANY, INCORPORATED

GENERAL  ELECTRIC

U.S.A.

Success stories of
CARBOLOY
CREATED-METALS



A CONCENTRIC-MAGNET element is the measuring mechanism of this new-type, portable current recorder, shown with cover removed. Because they possess lasting, higher energy, Carboloy Alnico permanent magnets in small sizes made possible a simplified element design . . . effected a 10-pound weight reduction in the recorder.

Magnets . . .
to make instruments behave

To detect an overloaded electric motor, or to accurately measure the output of a power station, recording instruments must be highly sensitive . . . yet able to resist outside disturbances.

To get utmost accuracy, many instruments use Carboloy Alnico permanent magnets in either the delicate moving-coil mechanism or the stationary coil. In the instrument above, Carboloy Alnico helps cut errors; makes savings in materials, weight and space.

Carboloy Alnico is just one of the versatile Carboloy created-metals. Others include Cemented Carbides for cutting, forming, and wear resistance, plus the new Series 600 Chrome Carbides, especially for abrasion, corrosion and erosion resistance . . . and Carboloy Hvimet for maximum weight in minimum space, and for radioactive screening.

MASTERS IN METALS

Do you need a created-metal to overcome a production stymie? Step up output? Or to solve a product-design problem, perhaps?

Then contact Carboloy engineers, today. They

have at their fingertips all available answers on these metals.

And look to Carboloy metallurgists, too, to bring you even broader fields of use for these and future Carboloy created-metals.

"Carboloy" is the trademark for the products of Carboloy Department of General Electric Company.

CARBOLOY
DEPARTMENT OF GENERAL ELECTRIC COMPANY
11139 E. 8 Mile Road, Detroit 32, Michigan



ALNICO PERMANENT MAGNETS
for lasting magnetic energy
CEMENTED CARBIDES
for phenomenal cutting, forming, wear resistance
HVIMET for maximum weight in minimum space, and for radioactive screening

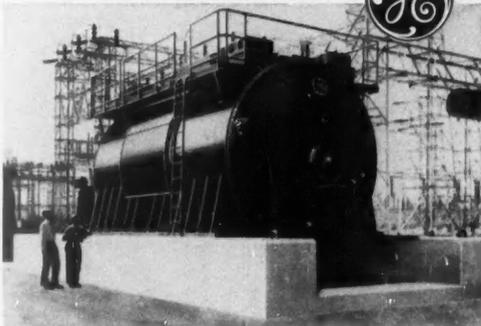
EVERYWHERE...



The General Electric Supply Corporation with offices and warehouses located in principal cities throughout the country continues its policy of constructive assistance to industry and the public it serves. Experienced technical specialists on Lamps, Lighting, Apparatus, and Wiring Materials in your locality are a ready and valuable source of technical information and assistance on your electrical equipment requirements.

GENERAL  ELECTRIC
SUPPLY CORPORATION

IN CANADA....



One of two Synchronous Condensers, Outdoor type hydrogen-cooled, rated 49,000 kva, 13,800 volts, 720 rpm, built at Peterborough Works, of Canadian General Electric Co Ltd and installed at a large transformer station of the H. E. P. C. of Ontario.

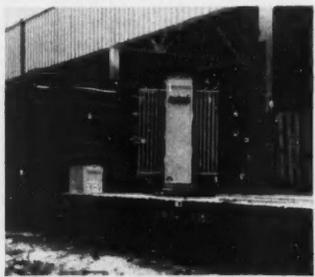
- 12** FACTORIES manufacture G-E products.
- 27** WAREHOUSES provide a convenient source of supply from coast to coast.
- 31** SALES and ENGINEERING OFFICES give complete nation-wide sales service.

CANADIAN GENERAL ELECTRIC COMPANY LIMITED

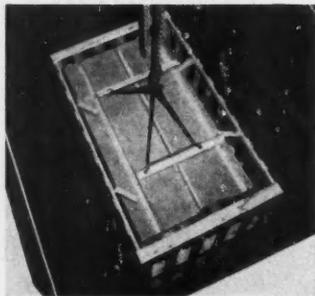
Head Office - Toronto—Sales Offices from Coast to Coast



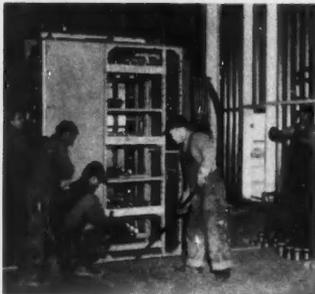
Standard "Specs" simplify planning, purchasing . . .



G-E "Packaged" power units arrive in easily-assembled units . . .



Easily hoisted or pushed to convenient location . . .



Easily installed—saves vital manpower hours . . .



ONE OF WORLD'S BIGGEST MANUFACTURERS expands quickly with G-E "packaged" power units, as shown above and left. Note that your power system can be installed before completing construction, giving you ample power to speed the rest of the job.

Here's how packaged power equipment speeds plant expansion

No matter how much more production you need *now*, or will need in the future, here are four good reasons for investigating General Electric's "packaged" power equipment today:

SAVES TIME. Order standard G-E power equipment for your entire system early—install the pre-assembled units quickly. No waiting for "missing links." Easy planning, easy installation and operation. Releases valuable time of key men for other important duties.

REDUCES COST. In many cases, 50% to 80% less copper needed for plant wiring. Flexible; eliminates expensive "hand-made" systems. Cuts costs at nearly every step, from purchasing to maintenance.

AVOIDS TROUBLE. G-E engineered "packaged" units arrive at your plant ready for use. All components are completely co-ordinated and metal-enclosed. Helps prevent shut-downs due to power failure, provides greater personnel safety.

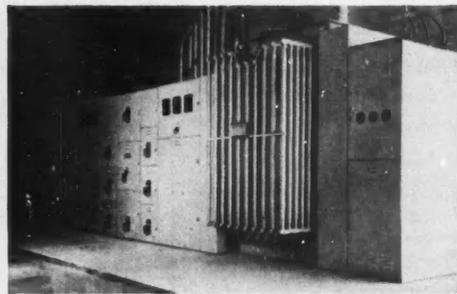
SAVES SPACE. No more need to clutter precious plant space with sprawling, dangerous open switchgear and wiring. G-E "packaged" units are compact. They can be put in convenient locations: near machines, in "unused corners."

Get your vital electric power equipment in packages. Install the units like machine tools. For more information, call your local G-E Apparatus Sales Office—or write to General Electric Co., Schenectady 5, N. Y.

"Electric Power for Industry's Third and Biggest Expansion"



For assistance in modernizing or expanding your electrical system to meet today's greater production, send for this new 24-page booklet. Ask for Bulletin GEA-5600.



And in a fraction of the time usually required you have a complete electric power system.

GENERAL  ELECTRIC

854-37C