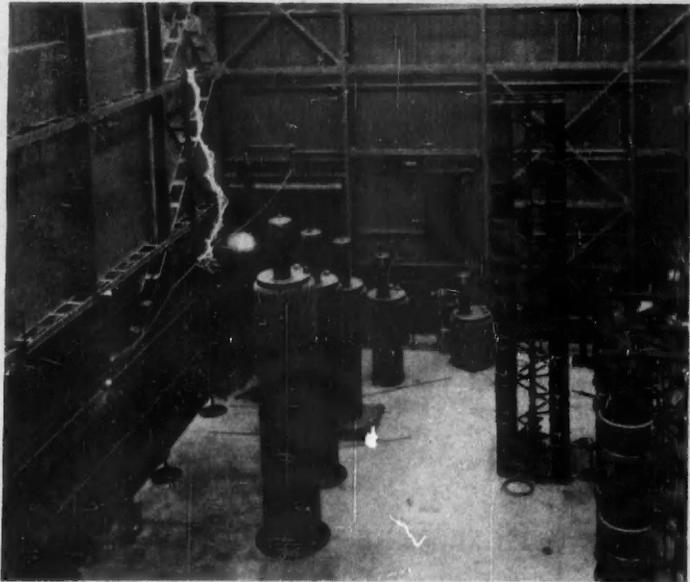
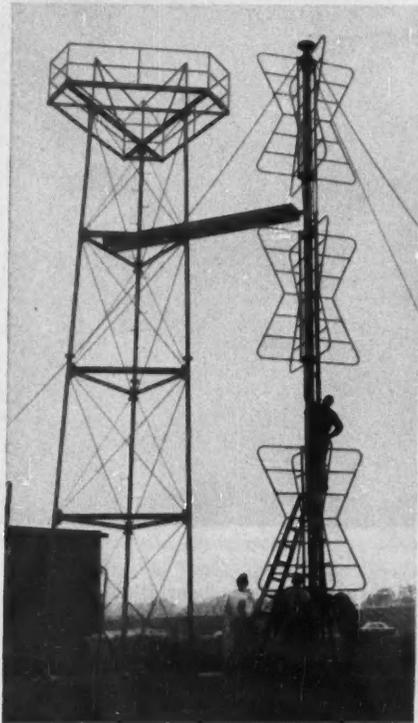
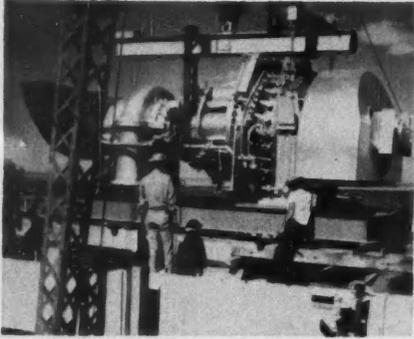


**GENERAL
ELECTRIC**

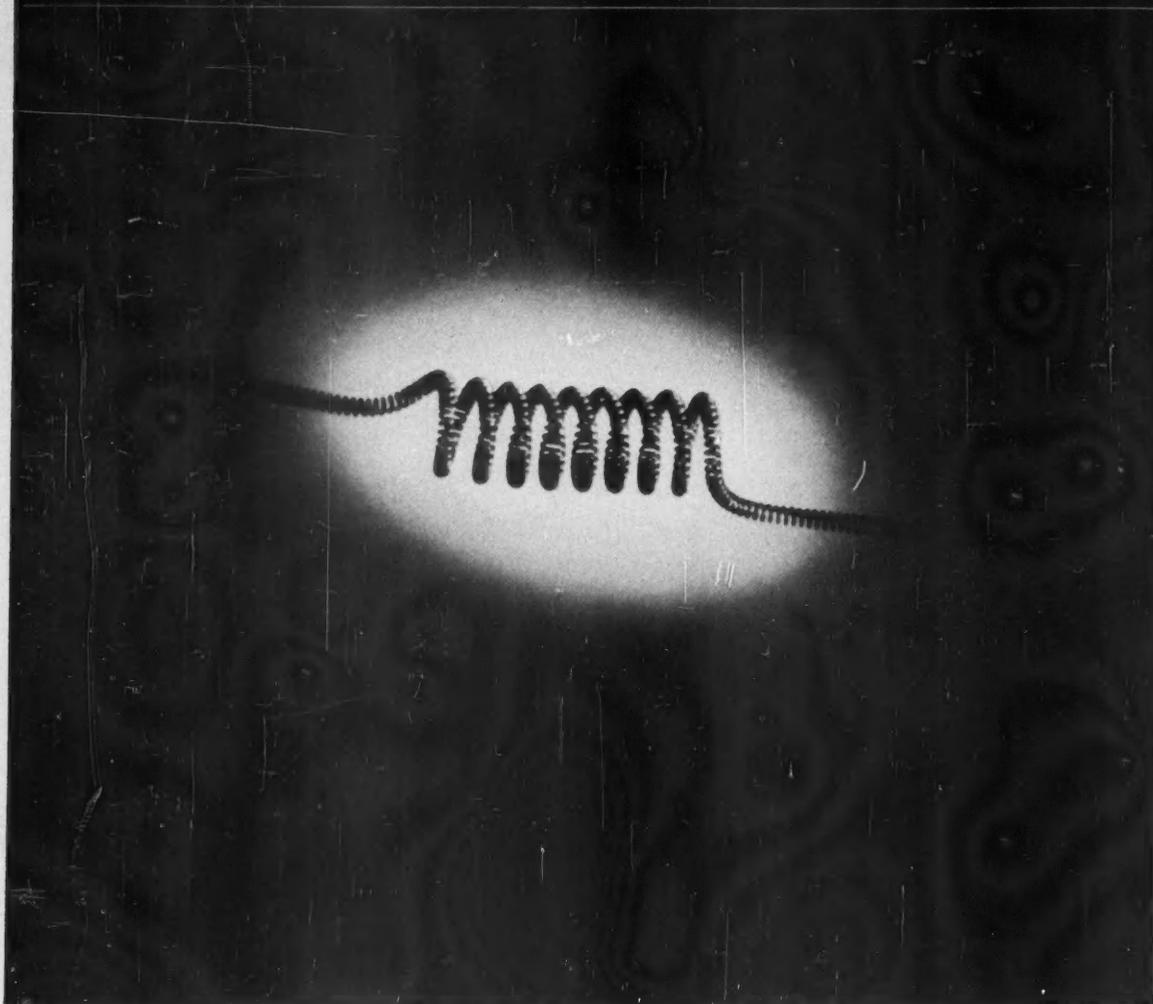
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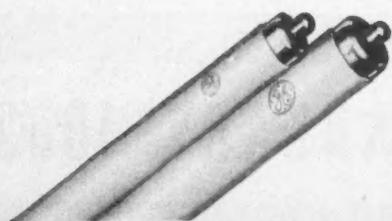
RESEARCH AND ENGINEERING PROGRESS • 1952

JANUARY 1953

You expect the best value from G-E fluorescent lamps



**Extra twist squeezes more
light from G-E slimline lamps**



The electron flow that lights a fluorescent lamp is started by a special chemical mix held on tungsten filaments at each end of the lamp. How long the lamp lasts depends in part on how long the chemical clings to the filament. In most lamps, the filament is twisted into a double coil, to hold a quantity of the mix in a firm grip.

General Electric goes a step further by giving the double coil a third twist—making a triple coil. Used in G-E slimline and other G-E instant-start lamps, the triple coil holds more mix, and holds it more firmly. It gives you extra light for your money because it makes the lamps last longer. This is another example of why you can expect the best value from G-E fluorescent lamps.

You can put your confidence in—

GENERAL  ELECTRIC

REVIEW

RESEARCH AND ENGINEERING PROGRESS • 1952

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THE COVER—The huge concrete saucer at West Milton, NY—one of 1952's research and engineering advances—is the foundation for a 225-foot steel sphere, nicknamed "atom's apple," that will house an atomic power plant (page 11) . . . And in the high-voltage laboratory at Pittsfield, Mass., flash-over on insulator strings spaced up to 20 feet was accomplished in 1952

for the first time (page 26) . . . TV antennas are now modified to use the higher effective radiated power permitted, following the lifting of the three-year freeze on new television construction (page 42) . . . Gas turbines are finding new applications in industry—repressurizing oil fields and pumping natural gas from the Southwest (page 32)

THE GENERAL ELECTRIC REVIEW IS ISSUED IN JANUARY, MARCH, MAY, JULY, SEPTEMBER, AND NOVEMBER, BY THE GENERAL ELECTRIC COMPANY, SCHENECTADY, NY, AND IS PRINTED IN THE U.S.A. BY THE MAQUA COMPANY. IT IS DISTRIBUTED TO SCIENTISTS AND ENGINEERS THROUGHOUT INDUSTRIAL, CONSULTING, EDUCATIONAL, PROFESSIONAL SOCIETY, AND GOVERNMENT GROUPS, BOTH DOMESTIC AND FOREIGN. . . . THE GENERAL ELECTRIC REVIEW IS COPYRIGHTED 1953 BY THE GENERAL ELECTRIC COMPANY, AND PERMISSION FOR REPRODUCTION IN ANY FORM MUST BE OBTAINED IN WRITING FROM THE PUBLISHER. . . . THE CONTENTS OF THE GENERAL ELECTRIC REVIEW ARE ANALYZED AND INDEXED BY THE INDUSTRIAL ARTS INDEX, THE ENGINEERING INDEX, AND SCIENCE ABSTRACTS. . . . SIX WEEKS' ADVANCE NOTICE, AND OLD ADDRESS AS WELL AS NEW, ARE NECESSARY FOR CHANGE OF ADDRESS. . . . ADDRESS ALL COMMUNICATIONS TO: EDITOR, GENERAL ELECTRIC REVIEW, SCHENECTADY 5, NEW YORK.



ENGINEERING REPORTS:



MINING output has been increased by amplidyne control engineered into electric shovels and mine hoists, including giant strippers like this. Instant shovel response, plus faster accel-

eration and deceleration, cuts seconds off each pass, helps increase the daily yardage handled. At all speeds, electrical and mechanical components of your equipment are better protected.

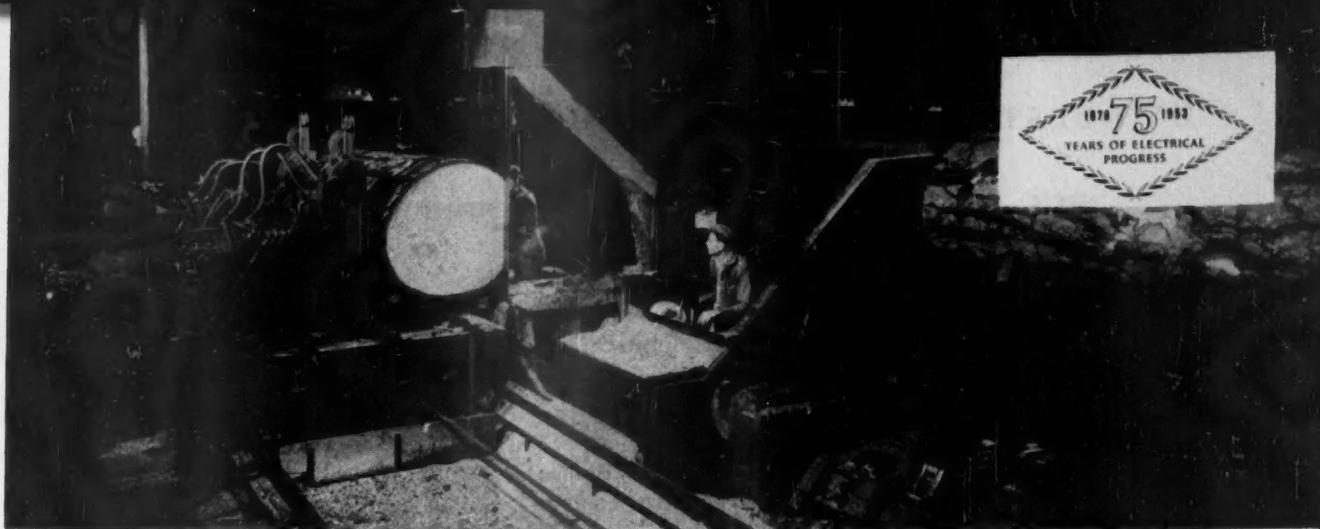
Engineers exploit "short circuits"



ORE-HANDLING, as well as blooming, rolling, pickling and other steel-mill operations, uses the G-E amplidyne. Ore bridge drives provide more accurate bucket control, fast trolley travel.



G-E ENGINEERS L. A. Umansky (left), Mgr. of Engineering, Industrial Engineering Dept., and C. B. Huston, application engineer, discuss an amplidyne application for a new steel-mill drive.

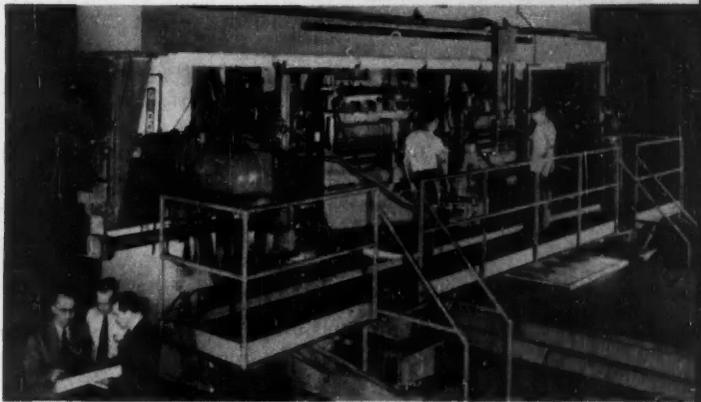


SAW MILLS equipped with amplidyne-controlled log-carriage drives produce straighter, smoother lumber at a faster rate. On the 21,500-lb log carriage shown, for example, uniform cutting speed is

maintained at 14 trips a minute. Current is limited to a safer maximum to protect your equipment. Among other amplidyne applications are paper-making machines and newspaper printing presses.



TEXTILE MILLS use amplidyne-controlled drives to hold automatically desired yarn tension and speed. Result: fewer yarn breaks, more uniform "beams," higher weave-room efficiency.



MACHINE TOOLS get added flexibility, speed and precision with amplidyne control. This 200-ton "skin mill" cuts in three dimensions to make an entire airplane wing in one operating cycle.

to boost your equipment output

An example of how G-E application engineering helps you cut operating cycles, improve machine precision

In 1938 General Electric engineers first applied the amplidyne—"the short circuit in harness"—to a cold-strip tension reel in a steel mill. Since then, they have engineered it into improved electric drive systems for practically every industry. Today, your equipment works faster and smoother, under more precise control, and with greater ease, safety and economy.

Essentially an "electrical lever," the amplidyne takes a tiny input signal and amplifies it instantly as much as 10,000 times, to make the most powerful machinery do its bidding. Controlling lift bridges and 200-ton machine

tools with pinpoint precision—rapidly accelerating power shovels and mine hoists without damaging equipment—holding desired speed and tension of moving material in rolling mills, paper machines and printing presses—these are but a few of hundreds of ways in which this versatile tool has been used by General Electric engineers.

You can put this application engineering skill to work for you by specifying "G.E." when you purchase electric apparatus. And on jobs where high-quality system engineering is required, G-E application engineers will apply their experience in working closely with you and your consultants. Call your local G-E Apparatus Sales Office early in the planning stage. General Electric Company, Schenectady 5, N. Y.

673-6C

Engineering Leadership gives you better electrical systems from—



MY QUESTION TO THE G-E STUDENT INFORMATION PANEL:

"What qualities do I need for a successful career with a company like General Electric?"

... HARRY K. LEADER, Lafayette College, 1954

Two answers to this question, given at a student information meeting held in July, 1952, between G-E personnel and representative college students, are printed below. If you have a question you would like answered, or seek further information about General Electric, mail your request to College Editor, Dept. 221-6, General Electric Co., Schenectady, N. Y.



G. C. HOUSTON, Manufacturing Services Division . . . While this is a rather broad question, I am sure it is one of real importance to any young man starting out in industry and looking forward to a position of responsibility in any of our successful industrial enterprises.

The mere asking of this question indicates that the individual has a definite goal or objective. This is important since progress can be made only if we attempt to reach a well-defined objective—even though it may be modified to some extent in the light of later experience. In G.E. we are looking for young men who have not only determined their objective but who are ready to work for it—who accept responsibility and have ability to get things done—who work well with others—to be a part of the team.

This calls for other qualities essential to long range success. We look for the enthusiastic individual, one not easily discouraged, and who can inspire the confidence of his co-workers. We desire individuals who show imagination and good judgment—particularly the ability to look ahead and maintain perspective beyond the immediate situation. Finally, we cannot overlook the qualities of loyalty and dependability since these are important in steering the individual through periods of discouragement which occur in every career.

When you decide on your business affiliation, make sure you associate yourself with a company that is soundly managed, that has a good business future, and that is the kind of company you would like to be a part of for the long pull.

E. S. WILLIS, Corporate Services Division . . . A successful career with a company like General Electric is built on the same qualities that contribute to success in any endeavor. However, in G.E., there is additional opportunity to develop these qualities because of the wide variety of training sources and openings which are available.

Basic qualities needed for any successful career include an open mind, willingness to accept responsibility, persistence, adaptability, co-operativeness, and common sense intelligence. Others such as physical well-being, ability of expression, and sound inquisitiveness also go to make up a truly qualified individual.

Most important is the fact that General Electric offers a wealth of opportunity to develop special capabilities and talents. The broad selection of training courses, in any chosen field, gives you a chance to sharpen your basic training and abilities. By decentralizing operations into about 70 different businesses, there is opportunity to see—in comprehensible dimensions—the full operation of the business. It means, too, that senior managers and young employees are more closely associated—a real advantage for the young man on his way up.

Also, our business requires specialists as well as managers. Thus, there are equal chances for success for those who concentrate in particular fields such as research, design, accounting, and planning.

So set your cap for a goal. And capitalize on your native qualities, which fortunately are different with each of us.



You can put your confidence in—
GENERAL  ELECTRIC

THE PRODUCT'S THE THING— BUT WHO'S BEHIND IT?

When a man wants to advertise an article he tries to think up a theme which emphasizes some constant quality in that article, something that the public will recognize as permanent and distinctive. Thus it is true in music, as Sigmund Spaeth writes in his delightful book *The Common Sense of Music*, that "the tune's the thing" by which individual compositions are recognized.

In engineering, the product's the thing. It is the product around which everything moves and toward which everything is directed. The scientist brings forth new knowledge from nature; the engineer forms that knowledge into products for people to have and to use. The engineer may improve present products or create new ones. But throughout, the product's the thing.

This is what makes engineering universal; this is why engineers are in the forefront of every advance.

Now as man uses the products he has, it is their performance which counts with him. The satisfactions and the profit which he enjoys give the product value. Reliability in operation establishes the product's reputation, and pleasing appearance brings gratification. Cost determines whether or not he can afford to own the product. All of these basic qualities come from the engineer. To the attainment of these, the career of the engineer is devoted.

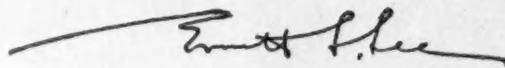
Yet the man who uses the products does so without thinking of the engineer who produced them. Little does the user know who created the idea in the first place, how it got into its present form, who will make it even better in the days to come, or how it is produced in ever-greater quantities through the design of ever-better production tools. All he knows is this: he has the product and it gives him satisfaction. The engineer is not spontaneously recognized.

Entwined with all of the past history of our country and bringing us into a position of world leadership today have been the continual contributions of the engineer. The engineer is born to serve, and he has served well. Our productivity is due to him and to those closely associated with him. He is at the foundation of our national strength, yet he and his fellow scientists represent in numbers less than four-tenths of one percent of our country's population.

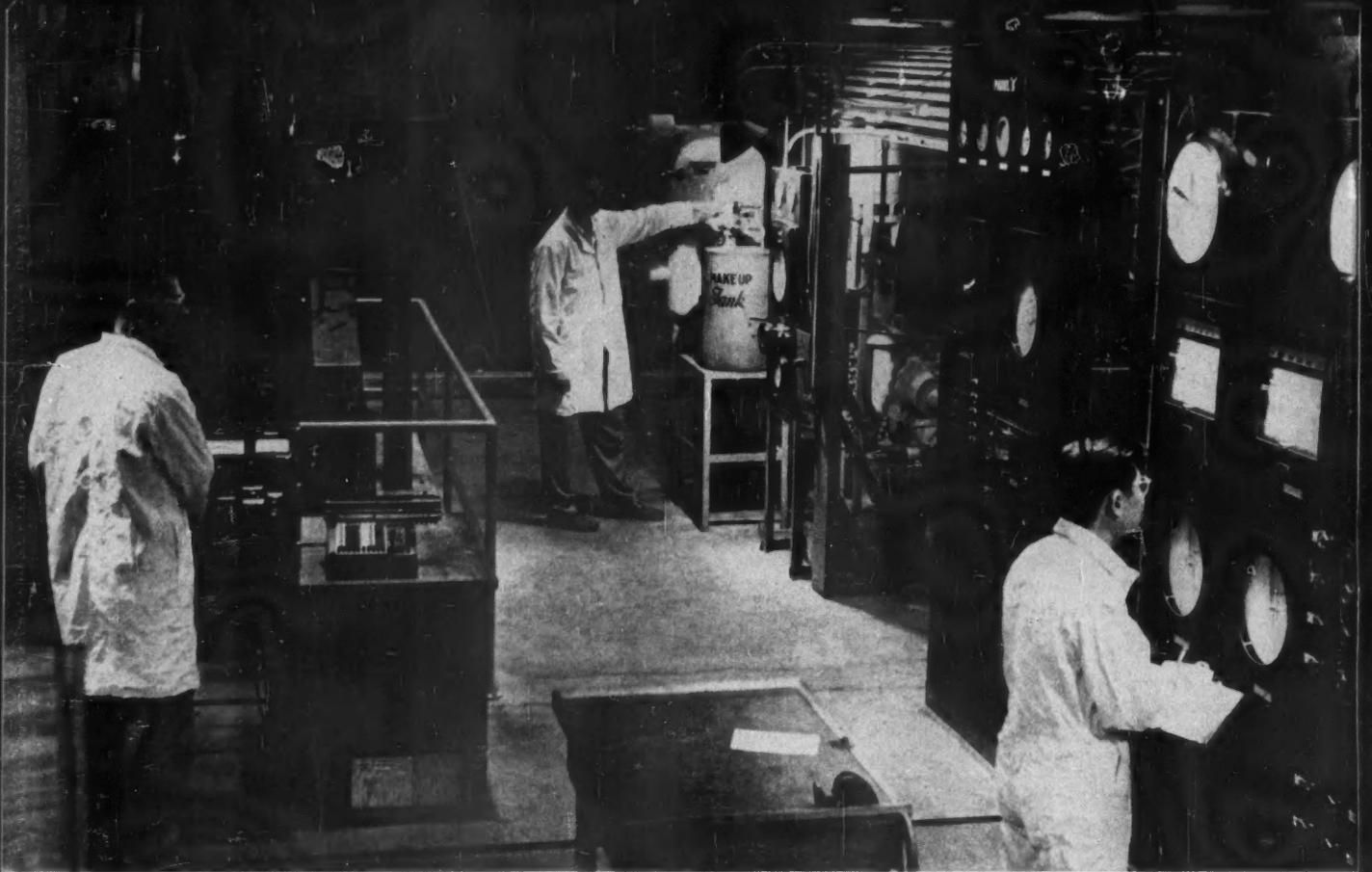
The engineer has been so busy *doing* things that he has not brought his story to the people of our country. Therefore they do not recognize the importance of his story, and thus far his recognition has been a problem for him alone. But today the seriousness of our world situation has taken the problem out of his hands. It is now a problem for the nation—engineers must be conserved for engineering, and their numbers must be increased.

This demands an earlier understanding of the engineer by the public at large. It demands that he receive the recognition due him in substantial degree. It demands that military assignments be made only for necessity in technical matters. It demands that secondary-school curriculums be complete with the necessary physics and chemistry and mathematics to provide the best training for those entering engineering schools. And it demands that those young people capable of advancing in engineering be eager to tackle the hard work which the training requires.

There is an imperative need for this understanding if our nation is to advance its present world position. The creative ability of the engineer is meeting its greatest challenge. But now the engineer must create another new product: a universal and spontaneous recognition of the engineering profession.

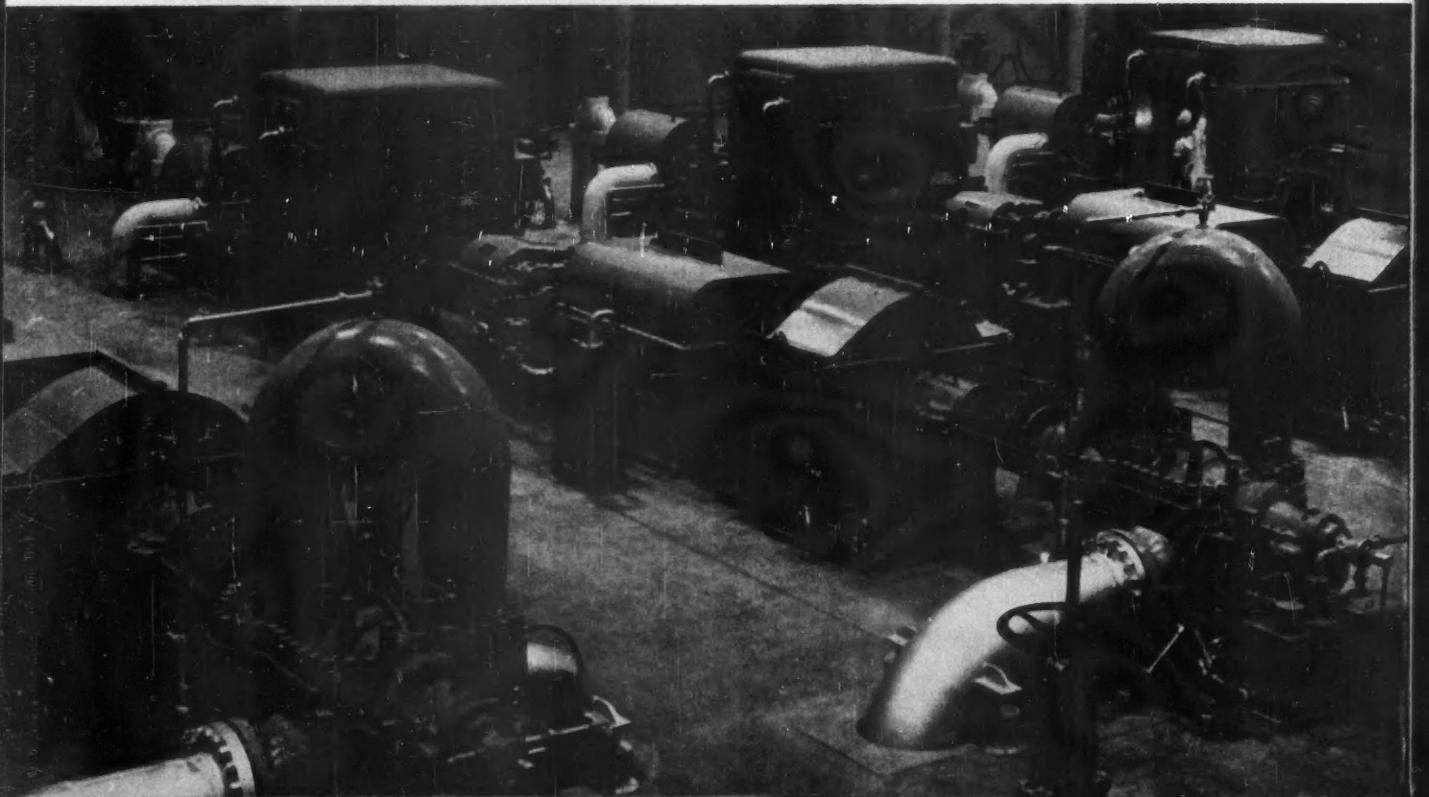


EDITOR



HEAT COMPARABLE TO THAT ENCOUNTERED IN A NUCLEAR REACTOR IS PRODUCED AND DISSIPATED IN THIS INSTALLATION

PURE HIGH-PRESSURE REACTOR COOLING WATER IS PROVIDED BY THIS PUMPING EQUIPMENT AT THE HANFORD WORKS





NUCLEAR EFFICIENCY of the reactor shielding materials is studied in this developmental facility at Hanford



ANALOGUE COMPUTER solves complex reactor heat-flow problems at the Hanford Works in Richland, Wash.

Nucleonics

During 1952, General Electric's sixth year of operating the plutonium-producing Hanford Works at Richland, Wash., for the Atomic Energy Commission, significant gains again were made in product output. Unit costs were reduced. Improvements in the operating efficiency of both reactors and separations units, plus completion of additional facilities, accounted for these achievements.

The process of separation and recovery of purified plutonium based on continuous chemical processing was placed in full-scale operation. This new operation displaces the former more costly batch process. Features of the new operation include continuous recycling of chemicals used in the separation and purification steps, increased yield and improved product quality, and recovery for reuse of uranium that has been irradiated in the piles.

Concurrent with this development, a plant for converting recovered uranium to uranium oxide was placed in operation. This completed a program started more than four years ago to assure the rapid return of processed uranium from Hanford to the AEC.

In conjunction with the new type of separations activity at Hanford, an

analytical and plant assistance laboratory was completed during the year. It will provide chemical and radiological analysis of test samples, and conduct nonroutine experimentation of a plant assistance nature.

In addition, the new Works Laboratory at Hanford that cost more than 14 million dollars neared completion. It will include major laboratories for work with radiometallurgy, radiochemistry, biophysics, and pile research and development, as well as facilities for all supporting services.

A hot semiworks plant was completed during the year to conduct pilot studies of chemical separations processes. The separations plants at Hanford for purifying radioactive uranium and plutonium involve complex engineering and process steps that for the most part must be carried out remotely behind massive shielding. Because of the complexity of these steps and the relative inaccessibility of the process equipment, it is necessary to conduct extensive pilot studies prior to development of full-sized plants.

The small-scale process equipment of the hot semiworks is contained within buried "cells," made accessible by

removing ground-level shielding covers after proper decontamination procedures. The equipment operation is remotely carried out from a separate building. Process and operating performance is relayed to the operating building by special instrument transmitters.

At midyear, the AEC announced a second major expansion program at the Hanford Works involving more than 400 million dollars. As a result of a newly instituted G-E design development program at Hanford, the most up-to-date technology will be incorporated in the new facilities. In addition, the new plants will be ready for operation sooner and will be constructed at less cost than would otherwise be possible. The new design development program will permit continuous integration of the results of research and technical developments.

Uranium Melting Furnaces

The vacuum furnaces used to convert uranium scrap to billets at the Hanford Works are among the largest in the nation. Within each furnace are two cylindrical sections, 6 and 12 feet in diameter, which enclose approxi-



CONCRETE SAUCER IS THE FOUNDATION FOR A 225-FOOT STEEL SPHERE, LARGEST EVER CONSTRUCTED, THAT WILL HOUSE AN ATOMIC POWER

mately 450 cubic feet. Each section is three feet high and the smaller is mounted eccentrically on the larger. Four crucibles, heated by water-cooled induction coils, discharge molten metal into molds supported and indexed on a 10-foot turntable. The molds rotate from hot to cold portions of the furnace on this turntable to decrease the cooling cycle and to facilitate unloading. Pressures below one micron were obtained during testing. Operating temperatures above 2000 F were reached. These remotely operated furnaces turn out large quantities of uranium safely, at low cost, and with high purity.

Nuclear Heat Removal

Complex heat-removal problems are studied in an installation designed to

create tremendous heat fluxes comparable to those found in the Hanford reactors. Heat supplied through 16,000 amp d-c is removed by circulating hundreds of gallons of water through the system every hour. Data collected by more than 100 meters, gages, and high-speed multipoint recorders are interpreted by the engineers in charge.

Cooling a Reactor

Large, dependable, accurately and automatically controlled flows of pure high-pressure water are required for reactor cooling at the Hanford Works. Pumping equipment to meet these requirements consists of a turbine, motor, speed increaser, fluid coupler, flywheel and a pump, all on a shaft more than 50 feet long. Each pump, of high-speed

centrifugal type, has a capacity of 8000 gallons per minute.

The nine-ton flywheel enclosed in a steel case is water-cooled to remove the heat which would be generated by air friction. The flywheel prevents rapid changes in pump speed when the normal electric drive fails and the load must be taken by the steam turbine. The fluid coupler permits operation of the flywheel and pump at variable speeds and is remotely operated. The speed increaser permits independent selection of the speeds of the electric motor and the pump. The motor is a totally enclosed air-cooled induction type.

The turbine is a geared noncondensing-steam type and is used for emergency drive and to bring all the equipment to operating speed before



PLANT FOR SUBMARINE PROPULSION

the electric motor takes over the load, thereby eliminating additional electric equipment for motor starting.

Testing of Shielding Material

Just as an industrial heating furnace requires thermal insulation to prevent the escape of heat, reactors require radiation shielding to protect personnel from radiation. Such shields are massive assemblies of neutron and gamma-ray absorbers, many feet thick, and weighing thousands of tons. The construction cost is enormous.

Considerable effort is being expended at the Hanford Works to develop more efficient and more durable shielding materials that will result in reduced construction cost and greater life expectancy for reactors.

The nuclear efficiency of alternate shielding materials is studied in an experimental facility installed in a Hanford pile shield. Panels of shield material containing radiation detectors are inserted into the shield aperture and radiation intensity is determined as a function of shield thickness.

Electric Analogue Computer

An analogue computer designed by Hanford engineers and consisting of hundreds of switches, resistors and circuits, is used to study pile heat-flow problems involving geometries too complex to permit analytical solutions without excessive expenditure of time. Its usage is based upon the analogy between flow of heat and the flow of electricity.

Mercury Jet Switch

A prototype mercury jet switch was developed for monitoring 48 thermocouples at a rate of 480 per second. The jet switch is capable of expansion to scan additional couples at the same rate. A spinning cone transports mercury from a pool as a jet against a set of fixed platinum 30-mil picket-like contacts. Of the material tested, platinum was the most insoluble in mercury. The switch can be used in scanning the output of any instrument or transducer whose output has been reduced to electrical terms.

The switch is arranged to work into a variable-limit alarm and safety shutdown system. A prototype mapping device consisting of a mosaic pattern on a cathode-ray tube to show changes in process variables has been used with the switch. With such devices, high-rate scanning becomes equivalent to continuous indication and limit control, making it possible to eliminate use of individual instruments.

Automatic Temperature Recorder

An apparatus was devised at the Hanford Works to permit rapid collection of reactor temperature data at many hundreds of locations, which records temperatures automatically at more than a four-per-second rate. The equipment consists of a switch that converts the analogue of thermocouple voltages into digital codes; a sensing circuit that actuates an electric typewriter of special design to record the digital coded temperature in map form for visual presentation; an arrangement that senses temperatures that are out of specified limits and changes the color

of the printed record at such times; a circuit and equipment which perforates the digital code into tape for a permanent record; and equipment that converts the perforated tape record onto punched cards for subsequent calculation.

Submarine Intermediate Reactor

The submarine intermediate reactor (SIR) under development at the Knolls Atomic Power Laboratory (KAPL), a laboratory operated by General Electric for the U. S. Atomic Energy Commission, is one of two projects for nuclear submarine propulsion sponsored by the AEC and the U. S. Navy.

During 1952 the AEC announced that a prototype of the KAPL power plant would be constructed at West Milton, NY, about 18 miles northwest of Schenectady. A prototype of the other reactor is being constructed at the AEC Reactor Testing Station in Idaho.

The KAPL power plant will use enriched uranium as the nuclear fuel, and will have a power output sufficient to drive a submarine at speeds in excess of 20 knots.

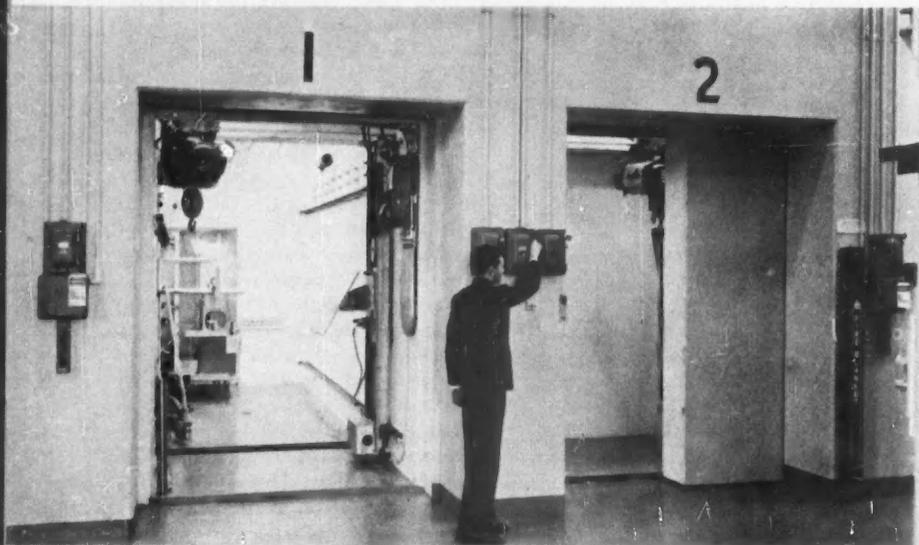
It will operate with intermediate energy neutrons and will utilize liquid sodium as the heat-transfer means. The KAPL approach requires, for the first time, knowledge of intermediate energy neutron behavior, thermal design of a liquid-metal cooled power reactor, and heat-transfer characteristics of liquid sodium, as well as effects of impurities on its corrosiveness.

Construction work is under way at the 4000-acre West Milton site for a land-based prototype of the SIR power plant. As far as possible, the reactor shielding, heat-transfer system, steam generators, controls, and auxiliaries will be virtually identical to an actual submarine plant, even to the extent of being installed in a section of submarine hull that will be submerged in water. The Electric Boat Division of the General Dynamics Corporation, Groton, Conn., is associated with GE as the submarine builder on the project.

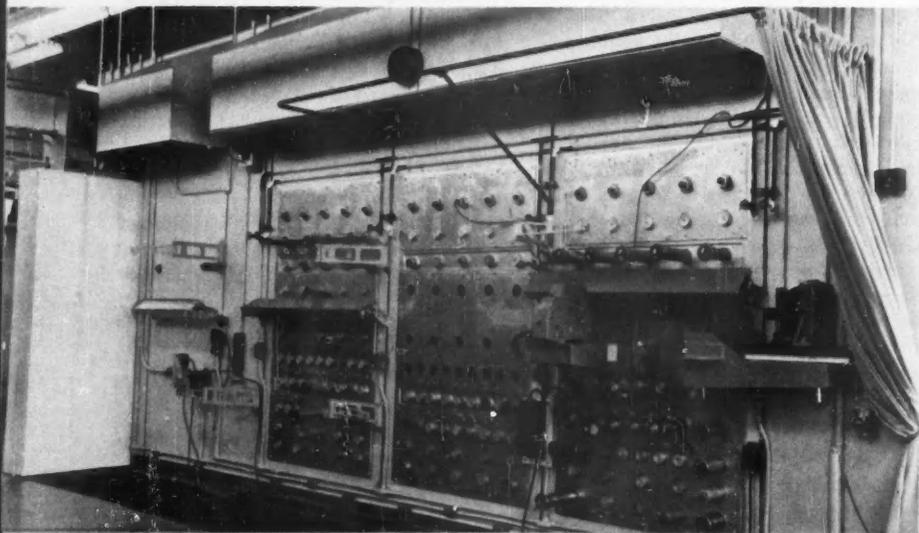
The building to house the power plant will be unique in that it will consist mainly of a 225-foot diameter sphere resting on a concrete foundation in the shape of a bowl. This unique structure is designed to provide protection during preliminary test operations in addition to the many safety controls of the reactor itself.



MERCURY JET SWITCH monitors 48 thermocouples at a rate of 480 per second. It is able to expand to scan additional couples at the same rate



MAGNETITE CONCRETE CELLS (above) provide protection during testing of radioactive materials in the KAPL Laboratory. Control face of a cell (below) for handling radioactive materials contains electrical, mechanical, and hydraulic controls



Radioactive Materials Laboratory

A new radioactive materials laboratory at KAPL provides highly complex mechanisms for metallurgical, chemical, and physical testing of materials after they have been in a nuclear reactor and have become strongly radioactive. These tests are important because the properties of materials may change after exposure to radiations and fission particles of high energy. The radioactivity remaining in the materials after removal from the reactor is dangerous to human beings. All work must therefore be performed from a distance and from behind heavy walls. Frequently the materials must be kept in a confined, sealed space to prevent spread of radioactive contamination by gas, dust, powder, or other small particles.

The new laboratory gives KAPL one of the best facilities in the country for high-level radioactive material testing. It provides for many different kinds of remotely controlled operations and tests, such as cutting, polishing, and etching; visual and microscopic examination; hardness and tensile testing; magnetic susceptibility; electrical and thermal conductivity; gas collection and analysis; and chemical tests of a specialized nature.

Betatron Experiments

The General Electric 100 megavolt betatron continues to be a valuable research tool. During 1952 it was used by KAPL to obtain nuclear cross-section data.

Earlier work had shown that a useful neutron beam could be obtained from the betatron when its high-velocity electrons were allowed to strike a target of uranium. The neutrons are given off in pulses of less than one microsecond duration (60 times per second), and each pulse contains neutrons of different energies. The time-of-flight for neutrons to travel to a given point outside the betatron depends upon their energy so that, by differences in their time-of-arrival, it is possible by electronic means to detect neutrons of different energies in separate circuits. Then by placing a test material in the path of the neutrons, determination can be made of the changes that occur when neutrons interact with this kind of material. Neutron capture cross sections vary with material and neutron energy.



NEUTRON SPECTROMETER UTILIZING NEUTRON-BEAM DIFFRACTION ANALYZES SAMPLE (CIRCLED). PROPORTIONAL COUNTER IS AT THE LEFT

Research

A new tool for studying the atomic structure of crystals—a neutron spectrometer—has been constructed in General Electric's Research Laboratory and set up at the atomic pile of the Brookhaven National Laboratory. This instrument utilizes neutron-beam diffraction in much the same way that an x-ray spectrometer uses diffraction of x-rays by crystals.

A collimated beam of neutrons from the reactor impinges upon a lead crystal surrounded by a six-ton shield of lead, boron, and paraffin. The neutron beam is diffracted by the lead crystal, and a selected monochromatic component of the diffracted beam strikes the sample to be studied. The monochromatic beam is again diffracted by the sample and registered by a proportional counter.

Although the neutron has no electric charge, and so does not interact with the electric fields of the atoms, it does have a magnetic moment and therefore does interact with the magnetic fields of the

atoms. Sometimes this magnetic scattering is three times that of nuclear scattering. Thus neutron diffraction provides a powerful means of exploring the magnetic structure of bodies.

Spiral Growth of Crystals

Crystals form and growth mechanism has long been a target of investigation by both experimental and theoretical physicists. It is now generally recognized that a crystal must contain imperfections to grow. Of the many possible kinds of imperfections, one that is particularly interesting from the standpoint of growth is the screw dislocation, a local spiral ramp arrangement of molecules.

Studies have been aimed at understanding spiral growth and learning how this growth can be controlled by special treatment. Motion-picture records of growing crystals revealed much data on the importance of screw dislocations in the growth process. The influence of screw dislocations on mechanical

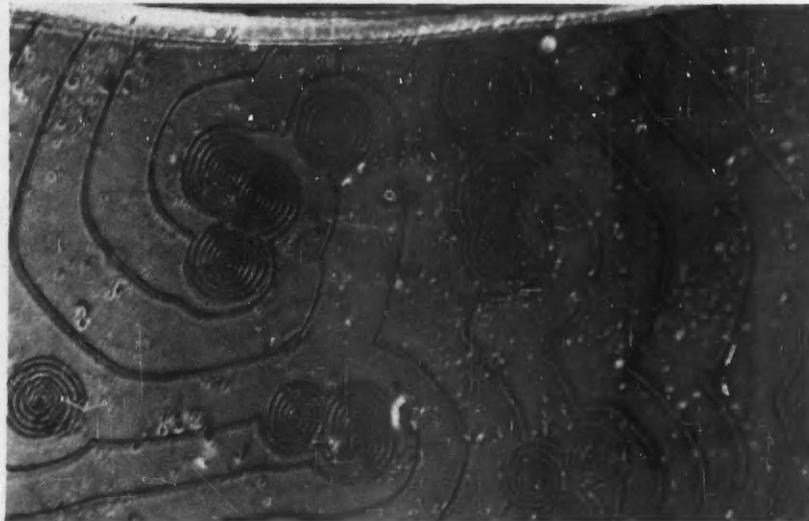
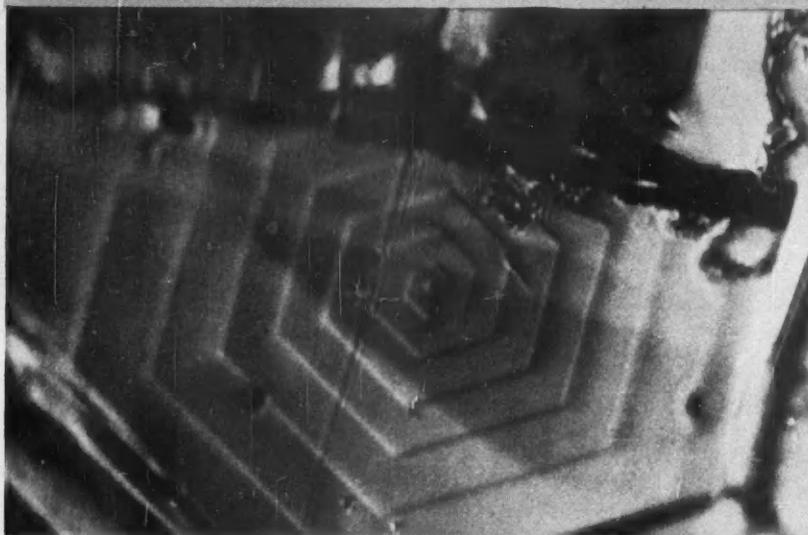
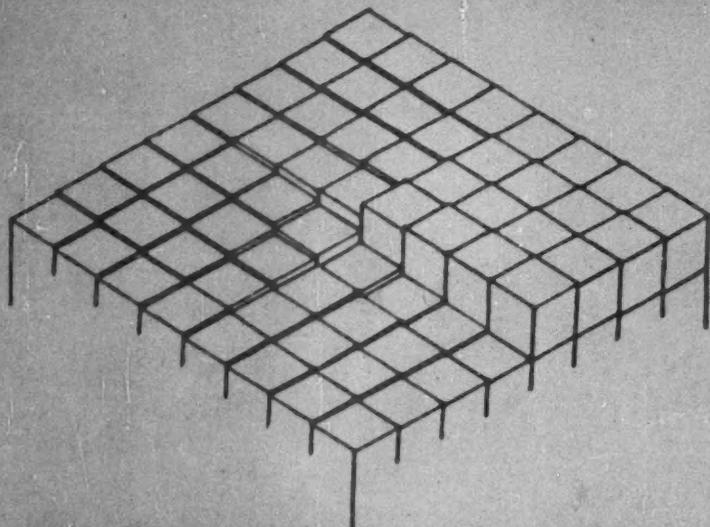
strength and other physical properties is being investigated.

Semiconductors

A field of rapidly increasing importance to the electrical industry is the study of semiconductors.

A basic feature of rectifiers and transistors is the p-n barrier, the boundary between a region of a semiconductor in which the conduction is by the movement of positive "holes" (p-type) and an adjacent (n-type) region where the conduction consists of the movement of electrons. The conducting properties of a semiconductor are determined by the amount and kind of impurities that are introduced in microscopic quantities.

A new method of producing p-n junctions in a crystal of germanium recognizes that the amount of a given impurity collected by a growing crystal depends upon rate of crystal growth and a property of the impurity—the segregation constant.



SPIRAL GROWTH OF CRYSTALS is shown in the diagram (*top*), pattern on the surface of a graphite crystal (*middle*), and interacting spirals in carborundum

Ingots of germanium containing more than 100 uniformly spaced p-n junctions have been formed by periodically varying the growth rate of the crystal from a properly "doped" melt. Ingots of this kind provide material for several thousand rectifier or transistor units, and can be grown in a few hours with little more effort than is required for the growth of an ingot of uniform conductivity. The equipment required is not complicated, and elaborate temperature control is unnecessary. Rate-grown junctions do not suffer from nonuniformities resulting from inadequate stirring, since it is not necessary to add impurities after growth has started.

Transistors made from rate-grown barriers have been found to have unusually good electrical characteristics.

Germanium and silicon, whose crystal structures are similar to that of diamond, have formerly been supposed to equal the latter in its lack of ductility. However, it was demonstrated recently that at elevated temperatures germanium and silicon are as ductile as nickel. Deformation apparently occurs by slipping of crystal planes. The increasing use of silicon and germanium in devices such as rectifiers and transistors makes a thorough study of the mechanical properties essential, especially since the electrical properties appear to be strongly influenced by deformation.

High-temperature Corrosion

As progressively higher operating temperatures are employed in heat engines, the problem of corrosion becomes increasingly significant. One aspect of this problem that has been studied is the role of vanadium pentoxide. Vanadium is a constituent of certain fuel oils. The presence of vanadium pentoxide results in an enormous increase in the rate of oxidation of steel. Because the rate of oxidation increases strikingly with the temperature, oxidation studies are of vital importance to the design of modern heat engines.

Martensite

A steel is hardened by heating it to a high temperature and quenching it in water. This causes the "martensite transformation"—iron and carbon atoms rearrange themselves so that the steel becomes hard and strong.

New evidence on the precise manner in which this atomic rearrangement is effected and on the kinetics of the

process was developed during the year. This data demonstrates the validity of the transformation theory.

Gaseous Diffusion

The leakage of gases through glass and other solid materials was carefully investigated during the year. Using the mass spectrometer as an analytical tool, the diffusion of helium through fused silica and other glasses of varying composition was studied. Owing to the great sensitivity of this device, measurements could be made to -80°C and lower for silicon dioxide.

Television Screens

Developmental transparent-phosphor television screens announced in 1951 have been improved. The elimination of scattering by the particles of the powdered phosphor is the inherent advantage of the transparent-phosphor screen. In the conventional screen a background haze is always present; this is caused by scattered room light, unless the room is darkened, and also by scattered light from the scanning electron spot. When these transparent-screen tubes are used with optical equipment, the picture is produced on a truly black background.

X-ray Diffraction

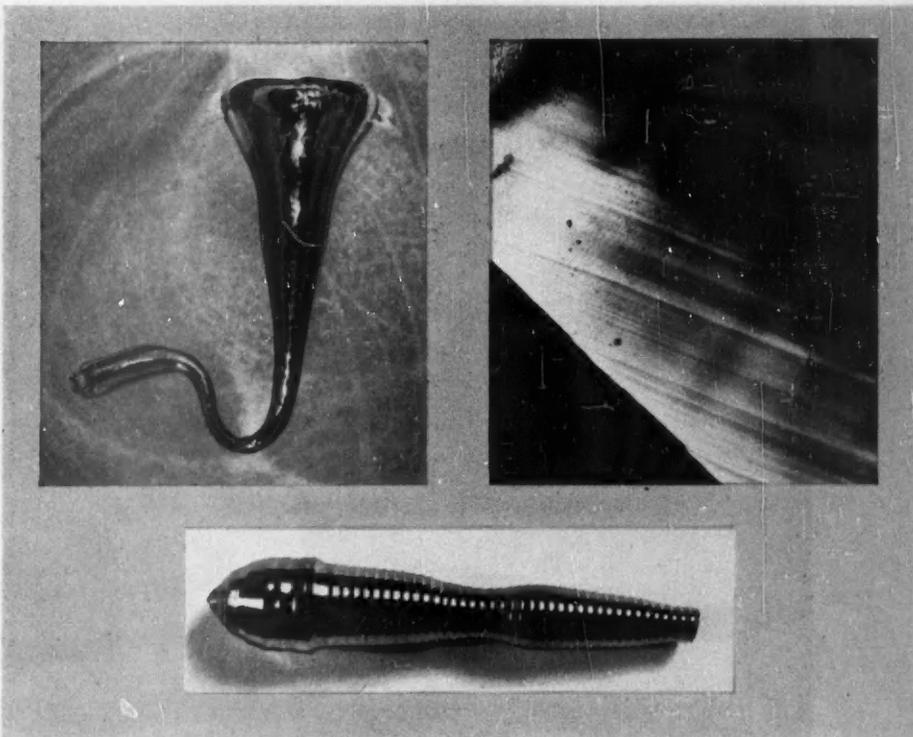
A new G-E direct-recording x-ray diffraction machine will help scientists analyze nonquartz crystalline soil components, and the destiny of phosphate fertilizer for soils. Two studies include soil phosphates crystalline behavior, and chemical alteration of phosphate fertilizers applied to soil.

Lubrication of Ball Bearings

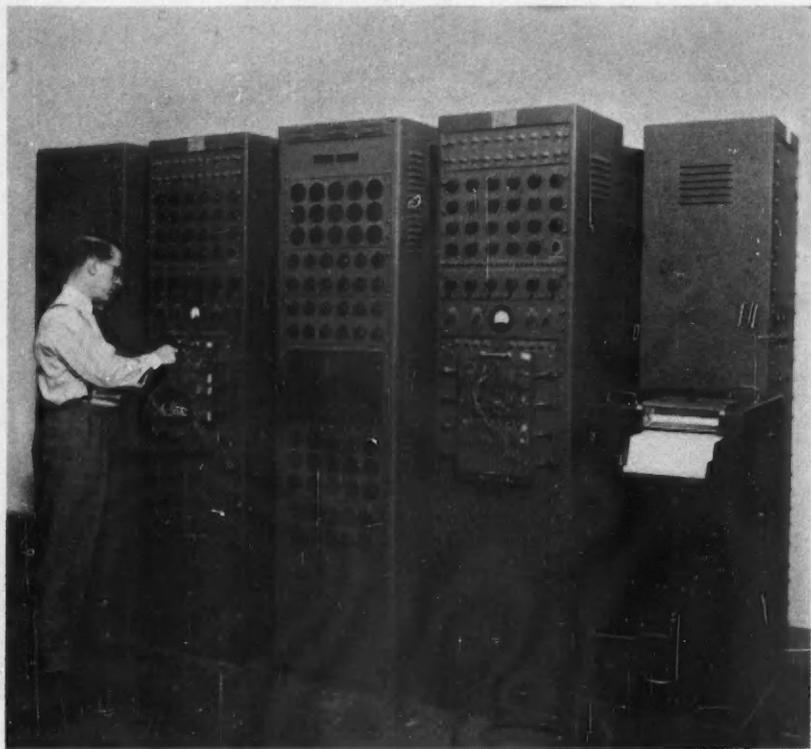
Fundamental studies of ball bearings have revealed that they can be lubricated with very minute amounts of oil. Quantitative relations were developed between running time on small amounts of oils and bearing size, speed, load, and viscosity and surface tension of the oil. From these relations, a No. 306 size bearing, the size in a standard three-horsepower electric motor, would run at 1800 rpm for about three years under ideal conditions on a single drop of petroleum oil. This drop would provide an oil film initially 0.0002 inches thick. Satisfactory lubrication is possible with an 0.000002-inch film which will just fill in the surface roughness of the bearing parts.



TRANSPARENT TELEVISION SCREEN (left), has excellent contrast compared to conventional powder screen in which a background haze is always present



GERMANIUM CRYSTAL (left) is ductile at 600 C. Deformed germanium crystal (right) shows slip lines. Rate-grown crystal of germanium shows multiple p-n junctions



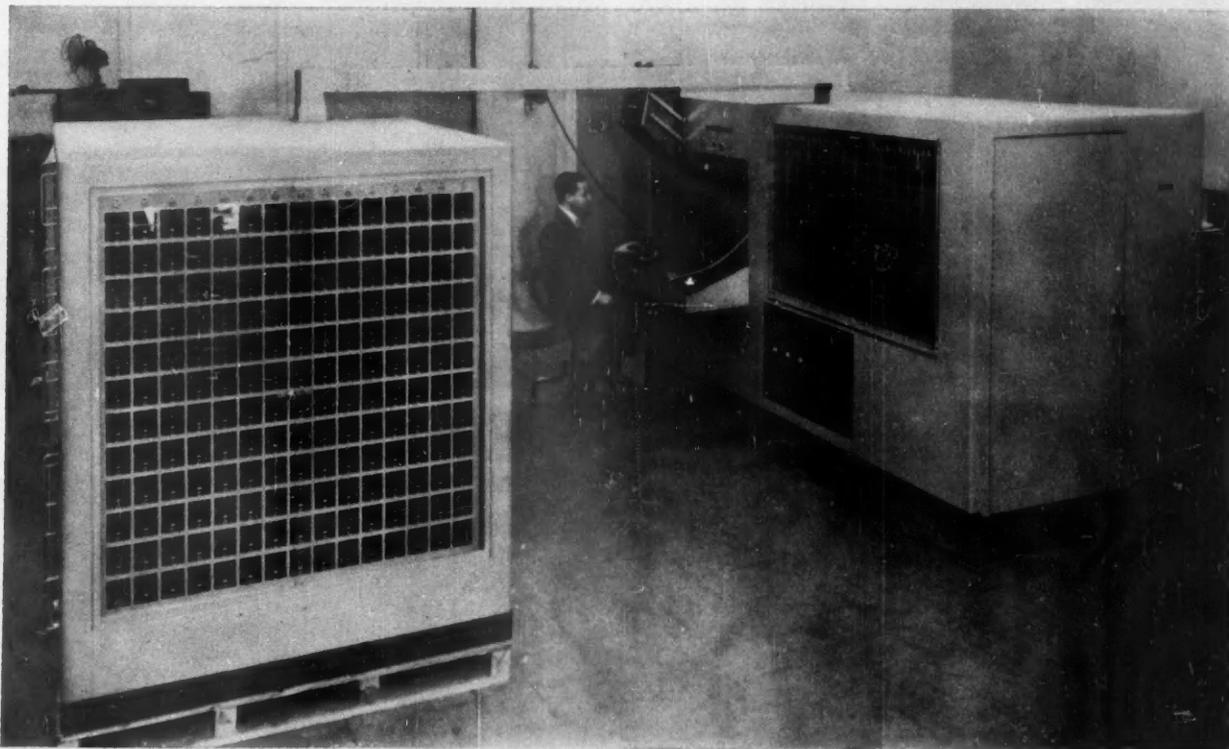
Computers . . .

. . . like the ones pictured here took on many and varied jobs during 1952. On the left is an electronic differential analyzer used for studying feedback control problems. One such problem involved the steady-state stability of low short-circuit ratio turbine-generators.

The transient analyzer (*below*) facilitates studies of lightning effects on power system equipment. It simulates lightning surges on a 100,000-kw turbine-generator and a unit-connected transformer; the rear panels represent 400 miles of transmission line.

On the right is a psychological matrix rotator for making improvements in Army personnel tests





Testing and Measuring

A recent addition to the Company's family of analyzers was a new electronic differential analyzer. Its use has resulted in a greatly increased and more thorough study of feedback control problems. These problems arise in such equipment as large turbine-generators, jet engines, tandem cold-strip steel mills, paper-machine drives, electric shovels, and complex wind-tunnel drives.

Following instructions prepunched in a deck of ordinary punched cards, a new card-programmed calculator installed in Schenectady will carry out a lengthy sequence of mathematical operations and punch or list results. Its large storage capacity and ability to accept unlimited instructions has proved extremely useful in carrying out engineering calculations. Typical applications of the computer are solving problems arising from electrical networks, the solution of polynomial equations, and the iterative solution of various partial differential equations.

The psychological matrix rotator, a large-scale analogue computer, was devel-

oped and built during the year for the Army's Personnel Research Section. Designed to make improvements in Army personnel tests, the computer detects misleading and erroneous questions and improves tests for the selection of a certain type of individual. Such a complete analysis previously required a period up to a year—now it can be performed in about a day.

Statistical output of the computer is a function affected not only by the numerical input but also by the experience of the psychologist using it. The psychologist applies his judgment in evaluating the solution.

Magnetic Flowmeter

Flow measurement of molten metals such as sodium and sodium-potassium alloys was made practical through development of a magnetic flowmeter. The flowmeter is entirely external to the flowing liquid and conducting pipe. Liquid metal flowing in the pipe cuts a magnetic field, generating in the fluid a small d-c voltage that is proportional to

the volume rate of the liquid's flow. Two wires welded to the pipe permit connection to an instrument that reads millivolt output of the flowmeter.

Force-measuring Equipment

Deflection of an elastic element, such as steel, is measured by an electric gage used in a remote-indicating weighing device. The equipment was developed for use with cradled dynamometers. Test results indicate that an accuracy of one-fourth percent of full-load rating can be obtained.

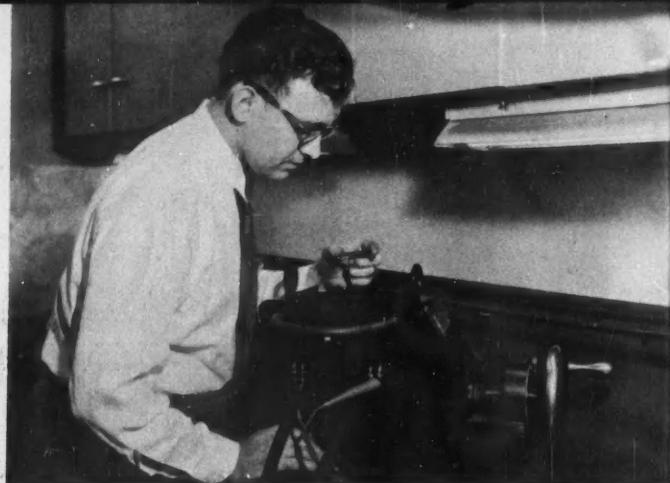
Advantages of this instrument are its remote-indicating feature, the small amount of space required at the dynamometer, and the possibility of applying its output as feedback to maintain constant dynamometer load.

Thermocouples

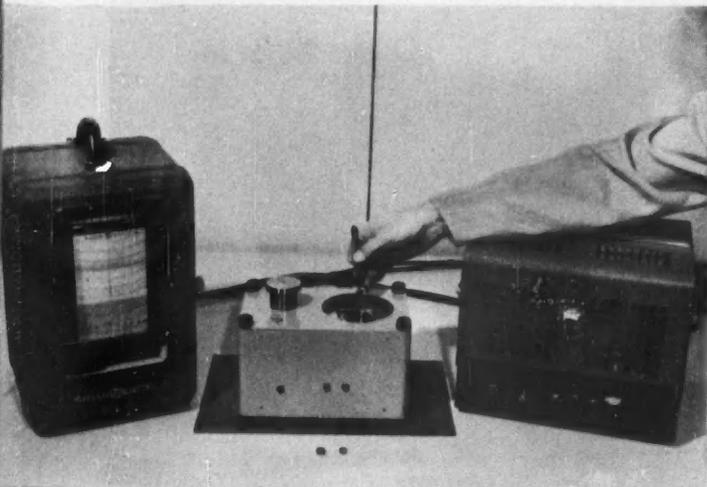
Two new thermocouple systems for jet-engine temperature measurements were developed. Both include swaged-magnesia insulation of thermocouples, leads, and harness assembly. This con-



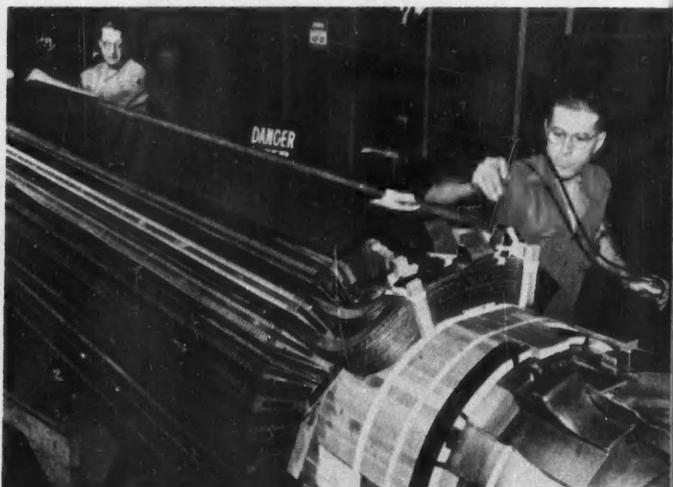
MAGNETIC FLOWMETER is completely external to the conducting pipe. It measures the flow of molten metals such as sodium



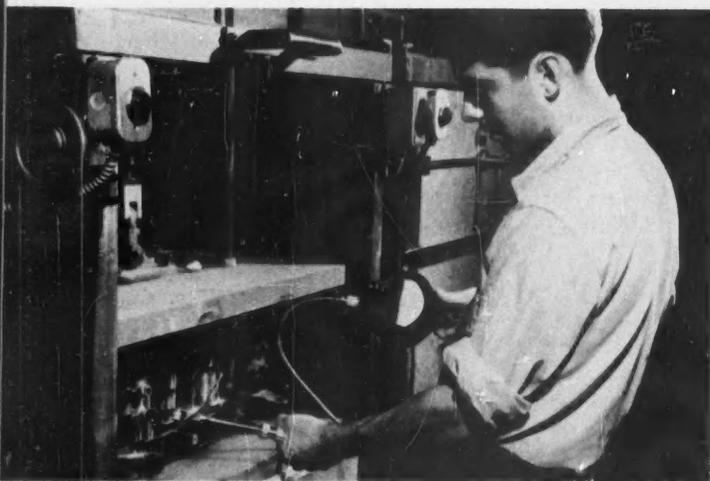
and sodium-potassium alloys. The isthmus electromagnet (above) had various improvements made on its yoke, poles, and coils



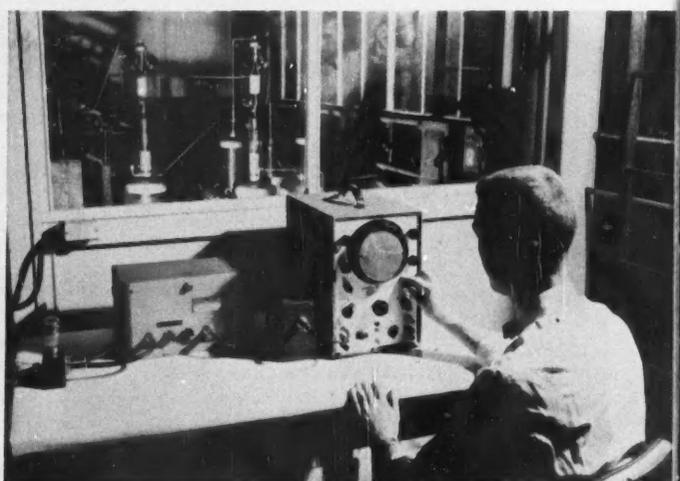
EXTREMELY SENSITIVE ball-bearing torque tester indicates presence of faults in tiny bearings that other techniques do not



reveal. Shorted turns of a turbine-generator rotor are accurately located with a flux-sensitive instrument (above)



HAND PYROMETER rapidly measures surface, liquid, gas, and molten-metal temperatures. The impulse corona detector (right)



combines simplicity and high inherent stability for making corona studies of insulation under a series of voltage stresses

struction has extended the average thermocouple life in jet engines from a relatively few hours to several hundred hours. One of the new designs has a balanced-resistance type circuit for use where a four-thermocouple assembly is required. The other embodies a new "ladder" type averaging circuit to accommodate any reasonable number of thermocouples.

Flame Detector

A new kind of flame detector utilizes the ability of a quartz filament to transmit light from end to end. Reaching into the tailcones of jet engines, it searches for flaming gases that might be burning there instead of in the combustion chamber. The detector combines a four-foot length of pliable metal-sheathed quartz filament with a photoelectric converter and amplifier. Energy from the flame is converted, amplified, and used to actuate an indicating instrument or graph recorder.

Primary Radiation Detectors

A group of primary radiation detectors for nuclear-reactor control applications was developed. In the design particular attention was directed toward operation of the primary detectors at high temperature and under high shock. Other considerations, such as gamma compensation and activation of chamber materials, were also taken into account.

Isthmus Electromagnet

The "isthmus" electromagnet, for measuring magnetic saturation by the well-known isthmus method, was improved during the year. Both yoke and poles are composed of soft-carbon iron specially annealed to produce a magnetic path of high permeability. The yoke uprights are mounted to permit adjustment, assure rigidity, and make good magnetic contact. Distance between the poles is controlled by a moveable yoke upright, and the two magnetizing coils are cooled with copper-wound cooling coils. Surface cooling by water or air, even in continuous service, helps prevent temperature rise from affecting the specimen under test.

Ball-bearing Torque Tester

A new ball-bearing tester detects the presence of dirt, irregularities, eccentricity, and other faults that may occur in bearings having a three-eighths to five-eighths inch outside diameter. The

bearings are tested in thrust only, according to newly established standards for ball-bearing testing. For production use, the tester will indicate torques exceeding a preselected maximum value above which a bearing must be rejected. And for laboratory use, a photoelectric recorder can be plugged directly into the electronic circuit to provide a continuous record of torque transmitted to the bearing's inner race.

Vibration Amplifier

Vibrations are measured simultaneously at multiple locations in a guided missile by means of a new instrument developed during the year. The equipment consists of six accelerometers, two cathode-follower units, and a dual-amplifier unit. When suitably mounted, the equipment will withstand shock and vibrations in all directions.

Shorted Turn Locator

An instrument was developed to detect and accurately locate shorted turns in turbine-generator rotor coils. To test a winding a small exciting current is applied to induce a turn-to-turn voltage in the winding. Flux resulting from the current in a shorted turn is then detected by a flux-detector coil probe especially designed to respond to flux over a small area. The small voltage output from the probe is next amplified in an extremely low-noise high-gain amplifier and used to operate an indicating instrument.

Governor Performance Recorder

Plots of a turbine's speed versus its governor motion are automatically made with a recently developed instrument. It consists of a narrow-range frequency recorder with a tilting chart carriage. The chart carriage is connected to the operating rod of the turbine, providing a governor-position axis on the chart. Frequency or speed of the turbine, as recorded by the recorder pen, is the other axis. From this recording the amount of governor movement per one-tenth cycle change in frequency can be measured.

Bazooka Tester

An instrument designed to test the trigger mechanism of the Army's rocket-launching bazooka unit went into production early in 1952. It combines a vacuum thermocouple and permanent-magnet moving-coil d-c instrument to

measure the energy generated by the bazooka's firing mechanism. The tester is read directly in milliwatt-seconds of triggering energy.

Quality Control

A new integrating device for use in continuous-process quality control was developed during the year. It provides a direct indication of the statistical mean (Bar-X) and the standard deviation (Sigma) over a predetermined time interval, thus reducing tedious calculations now involved in determining significant variations from the desired standard. Although the tester was initially developed to check yarn thickness, it can also be used for quality control of other materials.

Watt-hour Meters

The line of watt-hour meters with the magnetically suspended rotor (Type I-50) was extended to include two new forms. The first is a combination watt-hour meter and time switch for off-peak loads. It is furnished with either a single-rate or a double-rate register. The second is a universal two-wire/three-wire design that will significantly reduce the cost of converting the meter from two wire, 120 volts, to three wire, 240 volts.

Hand Pyrometer

The first thermocouple-type hand pyrometer with two ranges (0 to 500 F or 0 to 1500 F) was introduced during the year. It is for the rapid measurement of surface, liquid, gas, and molten-metal temperatures at points where permanent installations are undesirable. Range selection is accomplished by a switch that connects a shunt resistor for the higher range and also changes the position of a bimetallic spiral to provide the correct ambient-temperature compensation for each range.

Corona Detector

An impulse corona detector was developed during the year for corona studies of insulation under a series of voltage stresses—the kind encountered in such devices as radar components, welders, and special insulation-testing equipment. Corona is detected by observing on an oscilloscope only those pulses occurring on the tail of the wave. By this means it was possible to eliminate bridge-balancing equipment necessary for wave-front corona detection.



NEW SWITCHGEAR DEVELOPMENT LABORATORY AT PHILADELPHIA HELPS ENGINEERS DESIGN HIGHER CAPACITY APPARATUS FOR INDUSTRY'S GROWTH

Power

The highlight of the year in power engineering was the formal opening of the new multimillion-dollar Switchgear Development Laboratory in Philadelphia. Equipped with the world's most powerful and versatile equipment for short-circuit testing, the laboratory enables engineers to probe unexplored areas in the field of power arc interruption and related subjects!

Tests can be conducted at voltages ranging from 120 to 440,000 volts and up to 500,000 amp at 600 volts. Correspondingly lower currents at higher voltages—by direct and indirect testing procedures—can prove the performance of circuit breakers having interrupting ratings far above the highest ratings yet contemplated. (Further details of the Laboratory are in the July and September 1952 REVIEW.)

A new member of the outdoor power circuit-breaker family was introduced during the year. Known as the steel-clad impulse breaker, it embodies a new interrupter that functions on the impulse principle so successfully used in porcelain-clad impulse breakers for nearly 20 years. Breakers of the steel-clad type are now in production. They are rated 230 and 161 kv, 10,000,000 kva interrupting capacity, and have 3-cycle interrupting time and 20-cycle reclosing time. They have an oil content about half that of similar round tank breakers.

Almost two decades ago General Electric pioneered in high-voltage power transmission when it built the first 287-kv porcelain-clad impulse breakers for Hoover Dam. During 1952, orders were booked for the first 330-kv circuit breakers for the first 330-kv transmission lines in the United States. The breakers will be of the steel-clad impulse type rated 15-million-kva interrupting capacity, 1600 amp, 330 kv. Because of the wide phase spacing required at this high voltage, each pole of the breaker will have its own pneumatic operating mechanism to achieve minimum mass of moving parts necessary to obtain high-speed operation (3-cycle interrupting and 20-cycle reclosing time).

Tank-type oil circuit breakers in the 115- to 161-kv class were simplified and improved to provide unit shipment and to reduce weight and dimensions. Resultant savings in steel amounted to about two million pounds.

Another development in the line of power circuit breakers was a new line of breakers in the 14.4- to 46-kv range, embodying features to reduce maintenance costs.

A new series-capacitor protective device was introduced that short-circuits the capacitor only while transient, abnormal current is flowing. Without de-energizing the capacitor, its normal function is reinstated by the device as soon

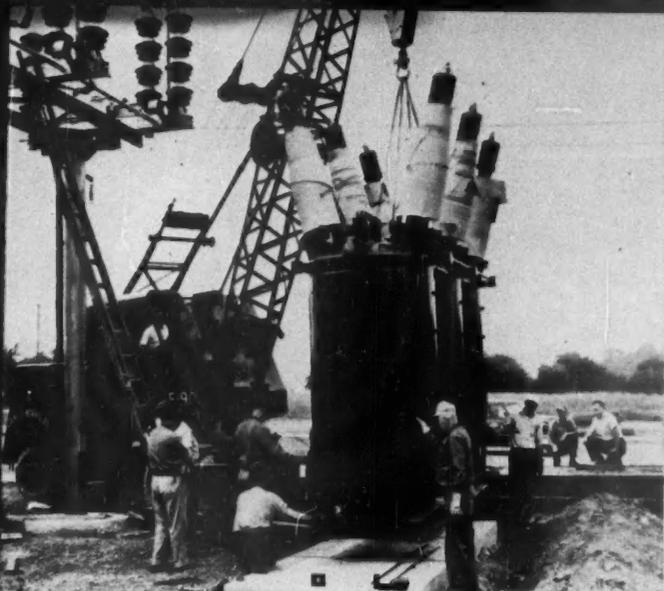
as the current returns to a safe level. This is accomplished regardless of atmospheric conditions by an arrangement of gaps, compressed-air flow through the gaps, and magnetic effects on the arc in the gaps. Series capacitors are thereby made more useful in high-voltage transmission systems.

In 1948 the first step was taken to provide air circuit breakers specifically designed for metal-enclosed drawout mounting when breakers with interrupting ratings of 15,000 and 25,000 amp were introduced. During 1952 this program was completed with the introduction of breakers having interrupting ratings of 50,000, 75,000, and 100,000 amp.

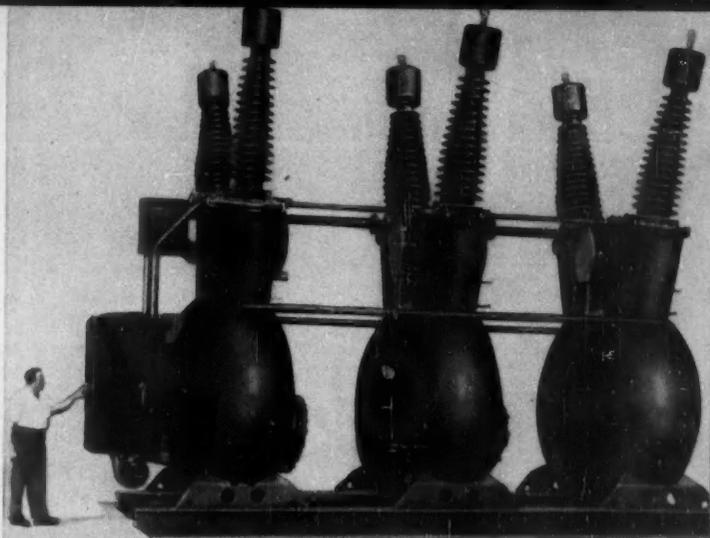
Design features of these new breakers have made it possible to reduce dimensions so that a standard-height drawout switchgear unit will accommodate three breakers of 50,000 or 75,000 amp ratings. Formerly only two 50,000-amp or one 75,000-amp breaker could be accommodated. Unlike their predecessor the new breakers have short-time ratings equal to their interrupting rating which, for the first time, permits design of completely selective low-voltage power distribution systems.

Protective Relaying

As a companion to the pioneer development of the 330-kv power circuit



BASE-MOUNTED outdoor power circuit breaker is conveniently transported to its site and installed as a complete unit



STEEL-CLAD impulse-type circuit breaker rated 10,000 mva contain only about half the oil of similar round tank breakers

breaker mentioned before. General Electric completed the design of the first all-electronic high-speed directional comparison carrier-relay system. It will respond within one cycle to any type of fault occurring anywhere within the protected zone.

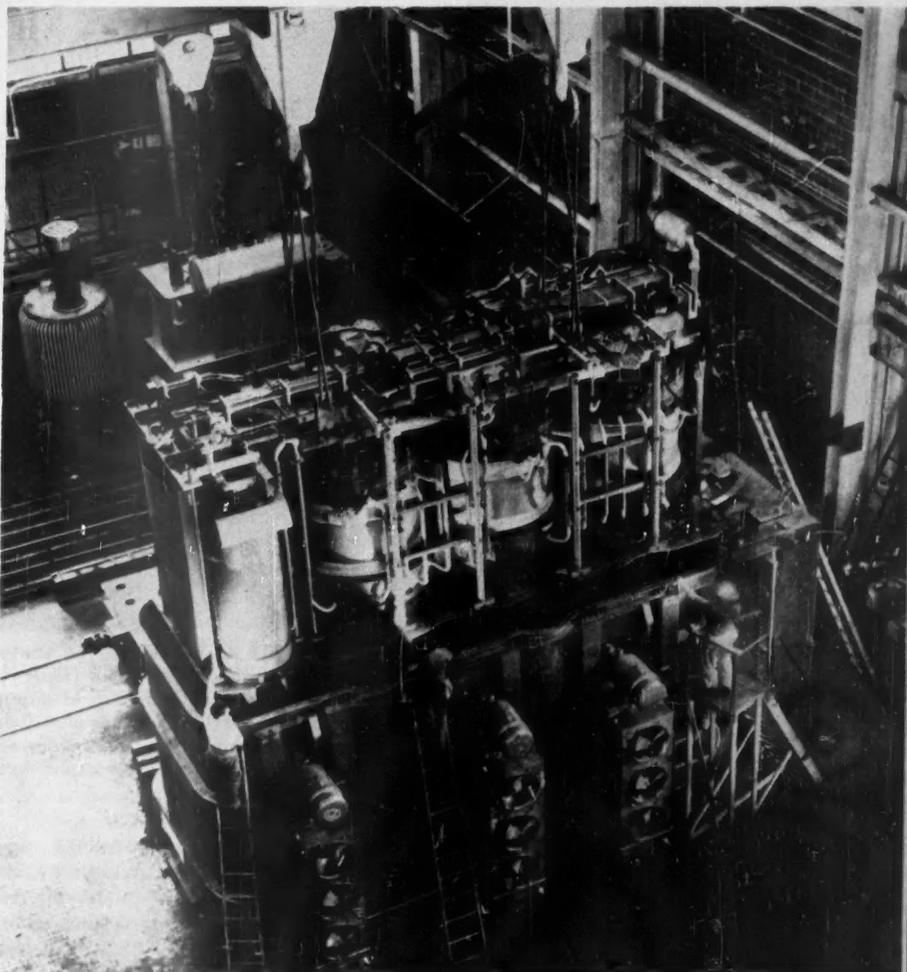
All relays using the wattmetric type of construction were redesigned during the year to utilize the latest type of laminations employed in the magnetic suspension design of watt-hour meters and direct-acting contacts similar to those used in other types of relays.

Outdoor Substations

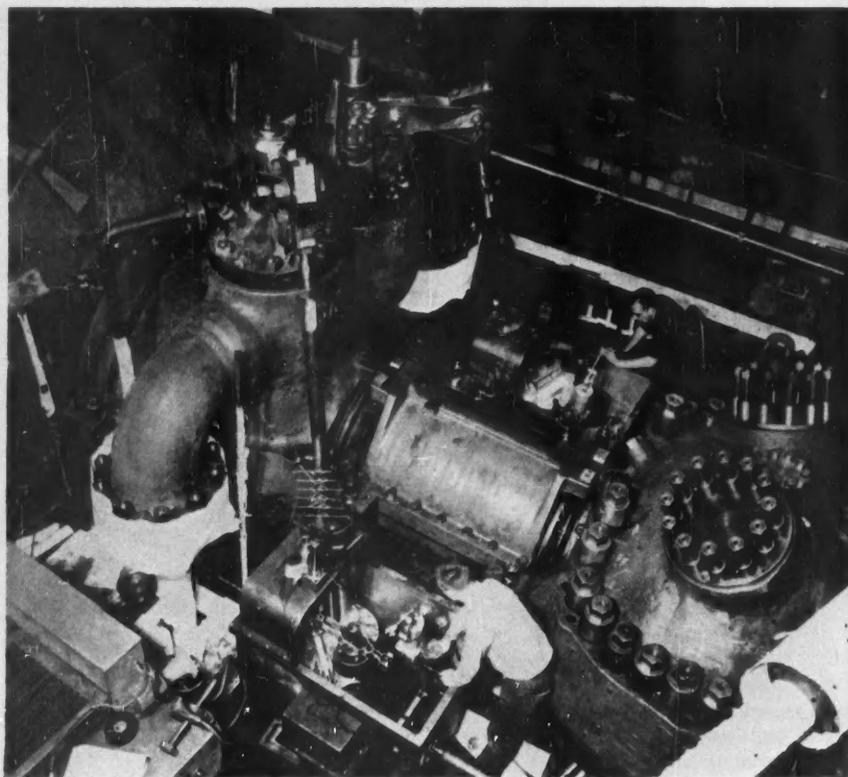
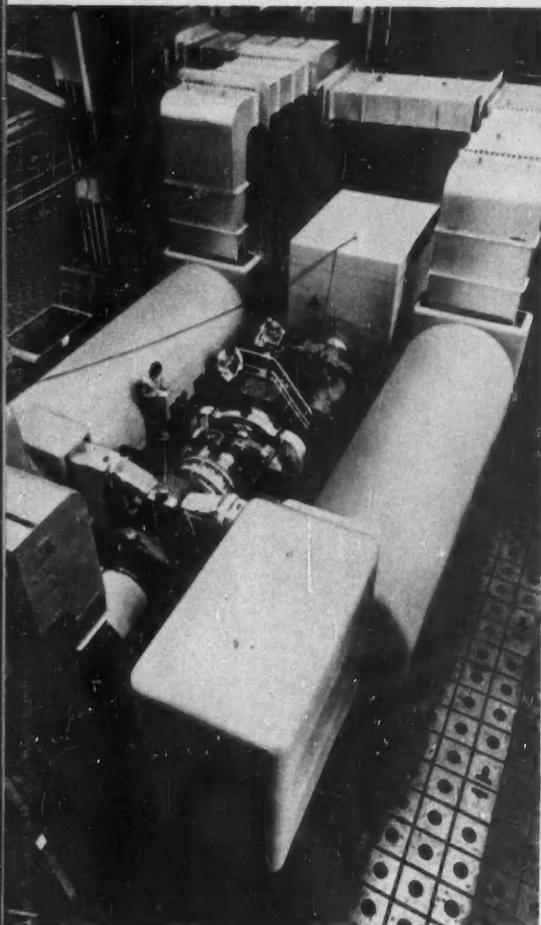
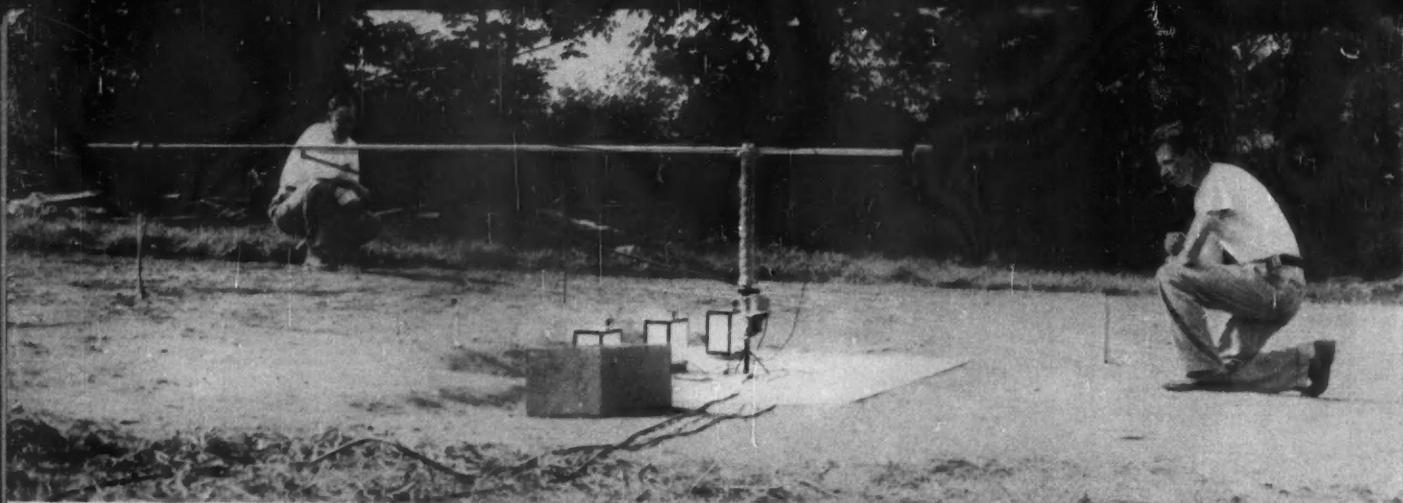
A previously undertaken project of standardization of outdoor-substation components was completed. Substations of any size and standard voltage rating, embodying practically any generally used circuit arrangement, can now be built entirely of standard trusses, columns, switch stands, and other components.

Transformers

General Electric is now designing the most powerful transformers in the world. Rated 300,000 kva, the two units will step up the voltage of a generator from 22,500 to 161,000 volts. Each unit will be 22½ feet high and will occupy 500 square feet of floor space. Assembled, each transformer will weigh 514,000 pounds. A special drop-frame railroad car will transport them to the installation site in their own tanks completely assembled except for bushings and coolers.



TANKING CORE AND COILS of largest autotransformer built by General Electric. It has a rated output of 156,000 kva and transforms voltages from 230 to 138 kv



NOTABLE ADVANCES in the power field during 1952 included acoustical studies of transformer installations (top)—engineers measure sound patterns to determine the best field location of apparatus. And on the left a 5000-kw gas-turbine undergoes test on facilities that duplicate the customer's installation. The turbine-generator (above) assembled for test is rated 145,000-kw and operates under the most advanced steam conditions for which a turbine was ever designed

The largest three-phase autotransformer built to date by General Electric was installed on the system of a Midwestern utility. Forced-oil-air-cooled, with an output rating of 156,000 kva, it transforms voltage from 230 to 138 kv. One of several unusual features is forced-oil cooling of the series winding

and main high- and low-voltage concentric-layer windings. Weighing 220 tons, this large transformer was shipped upright in its own one-piece tank, on a newly designed drop-bottom railroad car. This method simplified handling and reduced installation expense.

A feature of the largest self-cooled

transformer built in 1952 is its five-legged three-phase core. This construction allows maximum winding height with minimum height over the core. Handling and installation were again simplified; core and coils of the 75,000-kva unit were shipped upright in a one-piece tank.

Another power transformer, rated 25,000 kva, was designed to complete a transmission loop by connecting a 69-kv circuit with a 26.4-kv circuit. Circuit characteristics of the loop required that the transformer provide phase shift and voltage control. Both are obtained independently from separate control equipment.

Scale models were developed for making sound studies of power transformer installations. Represented in model form are the transformer bank and its physical surroundings, such as buildings, equipment, and ground contour. Sound levels can then be measured at any location. By predicting sound patterns for any topographical condition, including the effect of interference patterns, this method determines the best field location of apparatus. And if some form of sound baffling is needed, it can be tried experimentally with acoustically treated walls.

Power upwards of 60,000 kva supplied by motor-generator sets for testing power transformers is now stabilized to within 0.05 percent of voltage and frequency. The stabilized power supply—achieved through the application of electronic amplidyne controls to motor-generator sets—makes possible instrumentation of greater accuracy.

Production-line impulse testing of distribution transformers is now being done by the neutral-impedance method of fault detection. Improved methods of testing low-voltage windings are also used. As a result, even minute faults that might cause a transformer to fail can be detected and eliminated.

A new tank-wall high-voltage bushing for distribution transformers has improved electrical characteristics that allow cable to be brought into it from either side. The bushing eliminates exposed live parts, and permits safer, faster connections without tools.

Improvements in the quality and processing of core steel resulted in the fourth weight reduction in distribution transformers. Weights were reduced by 10 percent on units below 5000 volts.

Smothered arc-welding of network-transformer-tank bases now assures tighter transformers by eliminating any possibility of oil leakage. In this process the weld penetrates deeper and the tank wall is fused to its base at all points of contact.

Another development is a new header-section tube that reduces the number of

welds on the transformer by 90 percent. It is necessary to weld only one entrance and one exit on each side of the transformer.

Electronic transformers of a unique hermetic design are now being manufactured. They are approximately 20 percent smaller and lighter than similarly rated metal-cased hermetically sealed transformers. Core and coils of the transformer are completely immersed in an insoluble resin that provides a tough shatter-resistant solid casing when formed.

A load break mechanism designed for the open drop-out cutout for 7.8- and 15-kv service enables linemen to open distribution circuits under load more safely. It allows them to sectionalize and isolate lines, and to switch capacitor banks and other equipment. Other miscellaneous design changes in cutouts raised the interrupting rating of heavy-duty enclosed cutouts, 8000 and 12,000 amp rms at 5.2 and 2.6 kv respectively.

Regulators

A new line of single-phase step-voltage regulators was announced by General Electric in 1952. Features of the new units are their broader range of regulation and 32 five-eighths-percent steps. Compactly housed in round tanks, they are designed for pole or platform mounting.

The line of three-phase step-voltage regulators was extended to include ratings up to 2500 kva, 69,000 volts.

A new dry-type induction regulator was developed in ratings up to 4.8 kva, single-phase. By duplexing and triplexing, these units can be used for higher single-phase ratings and for three-phase ratings up to 14.4 kva.

Also during the year a large number of induction regulators were built to provide necessary control for guide lights at the approach to airport runways. First unit of this type built to Air Force requirements, it keeps runway lights operating even when the control cable is damaged.

During 1952 progress was made in the field of regulated unit substations. These units were installed by the Civil Aeronautics Administration (CAA) to control intensity of the slope-line runway approach lights at Kansas City and other airports throughout the country. Another first of its kind, the unit replaces the special induction regulator

and separately mounted assorted auxiliaries.

Steam Turbines

The first turbine-generator for Electric Energy, Inc., with a maximum rating of 156,250 kw, was completed and shipped during the year.

One of two 145,000-kw units built for a large East Coast utility went into service in 1952. Steam conditions—initial steam at 2350 psig, 1100 F, reheat to 1050 F—are the most advanced for which a turbine was ever designed. The turbine incorporates an opposed-flow reheat high-pressure element. Exposed to initial steam temperature, the center portion of the inner shell is machined from a solid stainless-steel forging. The two outer portions are chrome-molybdenum-vanadium castings, and are dovetailed to the stainless-steel part of the inner shell.

Another new development is a 26-inch last-stage bucket for 3600-rpm turbines. The bucket will have an annulus area 25 percent larger than that of the present 23-inch last-stage bucket, first put into commercial service in 1947.

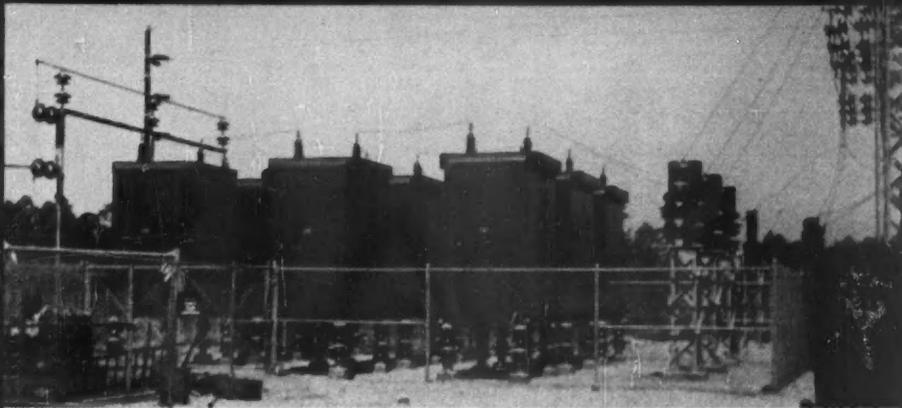
Mechanical-drive Turbines

Multistage mechanical-drive turbines, rated 500 to 2500 hp, were developed and placed in production. Improved design enables a wide variety of combinations for different service requirements to be more rapidly obtained from a high percentage of standard component parts.

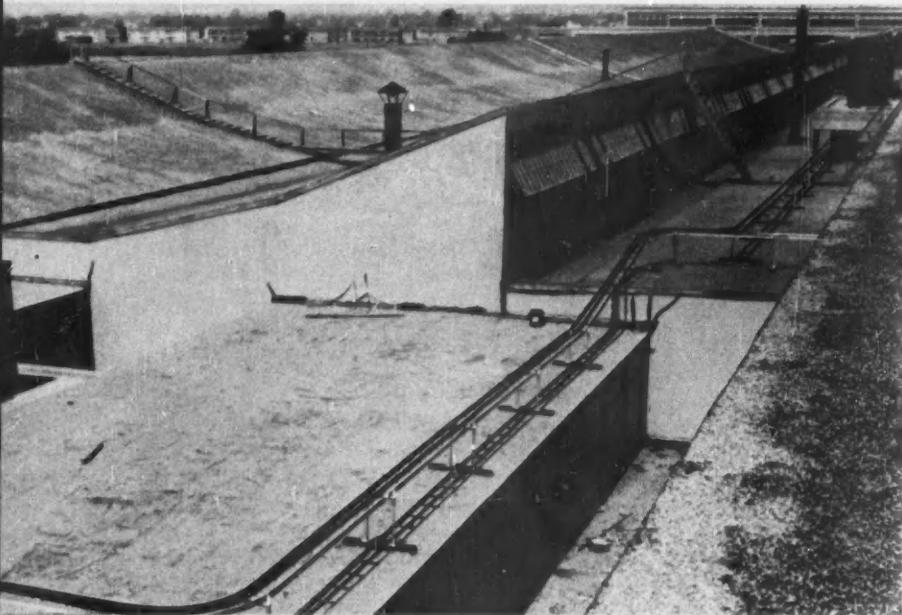
Turbine-generators

To meet the demand for larger capacity turbine-generators without increasing their frame sizes beyond shipping limits, improved cooling of the windings is necessary. And after several years of studies and development testing, a production design of a direct-ventilated rotating field is being built for 100,000-kva 3600-rpm generator to be completed early in 1953. Rotor field windings of the unit will be cooled by hydrogen in direct contact with the windings, thus eliminating thermal resistance of the insulation.

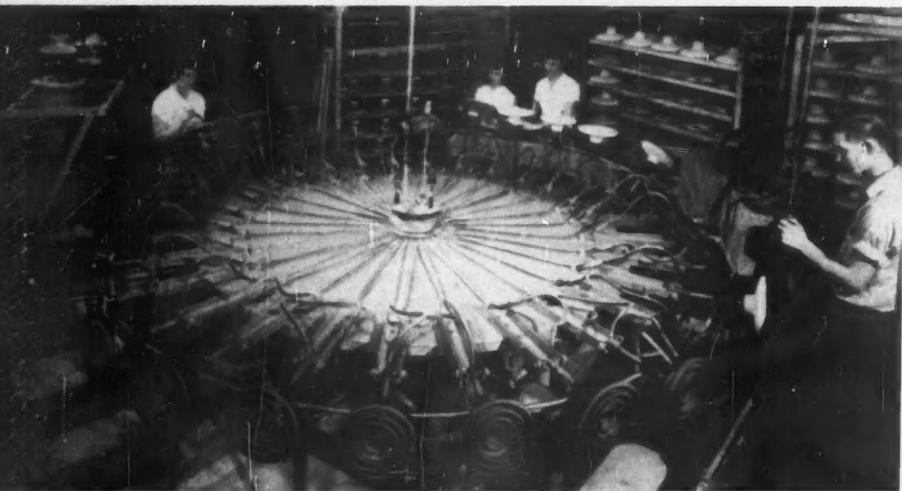
A new alloy called Cond-Al has enabled General Electric to manufacture turbine-generator rotors that are 35 percent larger than any of their type now in existence. Cond-Al is composed of aluminum, with extremely small quantities of iron, magnesium, and silicon. The lightweight alloy has a high con-



WORLD'S HIGHEST VOLTAGE—66-KV—HOUSED CAPACITORS PLUS BLOCKING REACTORS



INTERLOCKED ARMOR CABLE IS CARRIED OVER ROOF ON LIGHTWEIGHT CABLE RACKS



AUTOMATIC GLAZING MACHINE APPLIES A UNIFORM GLAZE OVER INSULATOR SURFACES

ductivity, and a high resistance to various stresses in high-speed high-temperature operation.

The first of four turbine-generator rotors to use the new alloy was completed in the fall. Each unit is rated 216,000 kva, 3600 rpm. Units rated at higher than 300,000 kva are now being planned.

Gas-turbine Testing

Gas-turbine testing facilities were designed to keep set-up time at a minimum. Three of the four permanent test stands are essentially identical to the customer's installation. In addition, testing facilities are provided for development work on corrosion and combustion problems and accessories.

Generators

The first of 12 large hydraulic turbine-driven generators for the Columbia River's McNary Dam was delivered in 1952. Each of these generators is rated 73,684 kva at 85.7 rpm, and each has a thrust bearing capable of supporting a 4-million-pound load which is 33 percent greater than the heaviest thrust load previously carried. These are not only the world's largest hydrogenerators, but the largest electrical machines in physical size ever built. Each rotor is 36 feet in diameter, and rotor and shaft together weigh one-quarter million pounds. The generator housing is 53 feet in diameter.

A lightweight 37½-kva a-c engine-driven generator with a completely static excitation-system was developed. The unit is used for ground power service. As a single-bearing generator—including its excitation system and voltage regulator—the complete system weighs only 60 percent as much as a conventional design giving equivalent performance.

The two largest engine-driven synchronous generators ever built in the United States were furnished a nitrate corporation in Chile. Both are 8750-kva 7000-kw 171½-rpm 6600-volt generators, each weighing 86 tons and having an over-all height of 21 feet, and a width of 24 feet.

In 1952 four synchronous condensers were furnished for ultimate use by the Atomic Energy Commission. Rated 50,000 kva at one-half-pound per square-inch hydrogen, or 60,000 kva at 15-pound per square-inch hydrogen, each condenser utilizes a wound-rotor induc-

tion motor for starting purposes. Separate hydrogen compartments are provided for collector rings of the induction motor and the direct-connected exciter. The compartments permit inspection without disturbing the main condenser hydrogen compartment.

During the year there was increased interest in the possible use of large steam-driven generators having considerably lower short-circuit ratios than in the past. Using modern voltage regulators, these lower short-circuit ratio generators will have a stability margin comparable to that of high short-circuit ratio generators operating without voltage regulators. Advantages to be realized include more kilovolt-ampere from the same frame size, reduced generator cost per kilovolt-ampere, and a reduction in total generator losses.

The first electronic excitation system for generators built by General Electric was placed in operation on a 40,000-kw steam generator. The system is a completely co-ordinated unit equipment. It includes breakers, a static magnetic voltage regulator, and parallel ignitron-tube rectifier with associated equipments. The power source for the rectifiers can either be an a-c generator, direct-connected to the main generator shaft, or the station auxiliary system.

Capacitors

The largest high-voltage switched-capacitor installation in the East was begun in 1952. General Electric and other manufacturers are supplying an Eastern utility with a total of 100,000 kvar of shunt capacitors that will be switched in five parallel banks at 110 kv. GE will furnish the two largest banks of outdoor open-rack equipment, each rated 24,750 kvar, and two outdoor power circuit breakers for switching the banks. The other three banks, each with a separate breaker, will be rated 16,800 kvar. This source of kvar generation was chosen after careful study of the relative economics of switched capacitors, synchronous condensers, and their various combinations.

A new line of dual-rated (ac-dc) specialty capacitors in drawn-oval containers was developed for commercial application. Engineering features make these capacitors smaller, lighter in weight, mechanically stronger, and lower in price than the rectangular-cased capacitors they supersede.

Tantalitic capacitors incorporate an



FLASHOVER on a 30-unit string of suspension insulators (left center). The new equipment at the high-voltage laboratory obtains data at spacings up to 20 feet

improved sealing method that results in longer life and improved stability. These capacitors are used in electronic equipment and communications circuits where there is a need for small size, wide operating-temperature range, and a reliability not obtainable with normal electrolytic-type capacitors.

A capacitor unit rated 7.5 kvar, 216 volts, single-phase, and suitable for 55 C ambient temperature, was developed specifically for underground secondary networks. Because of their size, the units are easy to install in a crowded vault. A galvanized steel rack equipped with provision for fuses has also been designed to facilitate the installation of these capacitors in vaults.

In the voltage rating of housed capacitor equipments a new high—66 kv—was reached in 1952 by two installations which each supply 5950 kvar, three-phase, 66 kv, on the system of a Southern utility. The capacitor equipments consist of 850-kvar single-phase housings that can be converted to 900-kvar three-phase 12.47-kv equipments.

A new load-break device on the 15-kv open drop-out-type cutout permits satisfactory disconnecting of capacitor banks up to 1080 kvar at 13.8 kv, or 975 kvar at 12.47 kv. Before, only about 45 kvar of capacitors could be switched with fuse cutouts.

Cable

Operating records over a period of years have shown that with increasingly heavy loads, lead sheath fatigue due to cable movement and internal pressures has been a major cause of trouble in the extensive underground duct systems used by electric utilities. A lead-alloy sheath of maximum long-time bend, creep strength, and maximum stability has been badly needed.

During the past few years General Electric carried out a broad program of basic research on lead-alloy sheaths, resulting in the present tellurium-alloys lead sheath that has all the desirable characteristics. Important, too, is its adaption to standard lead presses because it is less affected by extrusion

temperature and heat-treatment than other such alloys so far used for cable sheathing.

Because of the copper shortage, the technique of substituting aluminum conductors in varnished-cambic-insulated cable was perfected during the year. For equivalent load-carrying capacity, it means a larger conductor and a larger cable diameter but it does reduce weight in many cases. If copper continues scarce, the use of aluminum conductors as a substitute will increase.

Interlocked armor cable with non-magnetic armor is required for heavy-load single-conductor cables, and the recent substitution of aluminum for bronze armor has reduced weight and cost. Also, aluminum conductors can be substituted for copper, giving a further weight reduction. Another improvement has been the introduction of lightweight aluminum ladder racks on which the cable can be readily and compactly mounted in any position.

Power cables for low and medium voltages were introduced that use ultra-high-temperature insulations in the form of silicone resin and silicone rubber applied to a glass fabric. Spirally wound tapes of these materials insulate the conductors, with a silicone-base compound acting as a lubricant between the tapes. A high-temperature sheath is applied for over-all protection. The cables show remarkable resistance to very high conductor temperatures, especially those resulting from overloads of several hours duration.

Since butyl-insulated cable was first introduced with a temperature rating of 80 C, operating experience as well as a continuous research program has resulted in the development of an improved butyl-base compound that can be rated at 85 C for 0 to 8000 volts, and 80 C for voltages above 8000 volts. This has been accomplished with an improvement in moisture resistance making it an outstanding solid dielectric insulation for wire and cable. Thus for the first time a solid dielectric insulation has been available for power cables with a rating of 85 C at such voltages.

Bushings

A new high-voltage bushing was developed for 330-kv oil circuit breakers having an interrupting capacity of 15,000 mva. Although it has the diameter of a bushing rated 230 kv, its

flashover characteristics are comparable to the 330 kv rating. Its dimensions permit using smaller bushing-type current transformers and reducing circuit-breaker size.

Porcelain breakage is practically eliminated on a new line of bushings for use on power and distribution transformers in ratings through 69 kv, and for oil circuit breakers in ratings through 46 kv. Center clamping of the porcelain, rather than the flange-clamping method previously used, accounts for the high degree of strength.

The use of multiple-conducting stress equalizers in an oil-impregnated paper dielectric has reduced the size of a line of high-voltage bushings for use on power transformers and oil circuit breakers rated 69 to 161 kv.

Two developments by the Locke Department of General Electric contributed improved glazes and glazing techniques for insulators and bushings. An automatic glazing machine uniformly applies glaze over the insulator surface and insures the same treatment for every unit. This reduces pin spots and other surface imperfections. The second improvement is a brown glaze that produces exceptionally high mechanical strength and provides a smoother and more glossy surface texture than glazes formerly used in the industry.

During the year an extensive investigation was made of electrical and mechanical characteristics of switch insulators for use at service voltages in excess of 230 kv.

Small glass bushings with hermetically sealed caps and flanges are now being centrifugally cast at high speed with high temperature molten glass at a cost competitive with other types of bushings.

Sparkover

Sparkover data on rod gaps and insulators with spacings up to 20 feet were obtained in the high-voltage laboratory. A 50-unit insulator string was included in the tests. Previously, limitations of equipment and laboratory space in this country had restricted such data to gaps of about eight feet.

One of the 7500-peak-kv impulse-voltage generators and five cascaded transformers provided 1750 kv at 60 cycles for the test. And during the investigation a new, relatively simple method of measuring ultra-high a-c voltages was evolved.

Impulse Corona

A method was developed during the year that permits the study of corona starting voltage and in many cases the stress at which damaging corona appears. The method cancels out the high charging currents involved in many test specimens. These may be 1000 times greater than the corona currents.

Surge Phenomena

Research and analysis during the year further extended the concepts, theory, and analysis of the effects of switching and lighting surges on the design and operation of electric power systems. Three main areas of increased knowledge are: switching capacitive kilovolt-amperes with power circuit breakers; lightning and switching surge performance of large unit-connected turbine-generator installations; and the recovery voltage and short-circuit current characteristics of distribution systems.

Integrated Power Systems

The analysis of incremental transmission losses in integrated power systems was greatly simplified by the use of formulas developed by General Electric in co-operation with a large electric utility. These formulas express transmission system losses in terms of plant and interconnection loadings. In addition, transmission-loss formulas are valuable tools in evaluating alternative schemes in power-system planning.

Other Developments

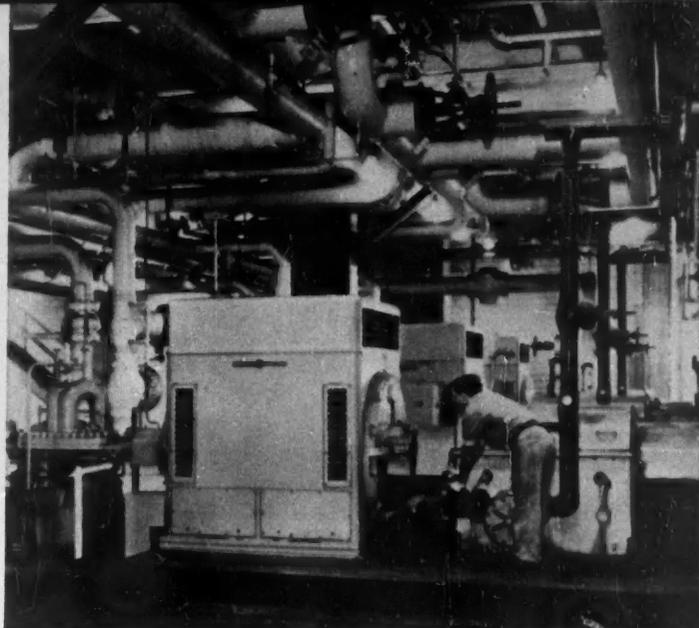
Several large installations of isolated-phase bus runs were constructed utilizing the new method of silver-plating aluminum conductor joints announced in 1951.

After considerable research a d-c power pack was developed for home use in forced-air heating and air-conditioning systems that utilize electrostatic air filters. It has an output of 12,000 volts at open circuit; 10,000 volts under a 230-microampere load. Operating directly from the 115-volt 60-cycle house circuit, it is designed to be hazard-proof should component failure occur.

A 30,000-hp test drive is being installed at a Midwest government project for testing supersonic propellers. The speed-increasing gear for the drive is capable of transmitting full power over a complete speed range of 330 to 12,000 rpm. Sixteen I-beam sections support the 78-ton gear unit.



SMALLER, LIGHTER—Fractional-horsepower motor (left) is 51 percent less per horsepower in weight than a former model



BOILER FEED pump motor of cubical shape has front air-discharge and minimum width for efficient central-station operation

Industry

The use of electric power in American industry is still growing, and growing rapidly. From 1950 to 1951, power consumption increased from 189.4 to 210.8 billion kilowatt-hours, or 11.3 percent. Factories, mines, and other industrial plants have consumed about 55 percent of all electric power generated in the country. Although complete statistics for 1952 are not yet available, it is well known that new records were established in this period.

However, the electrification progress in the industrial field was not only quantitative; many notable steps were taken during 1952 to broaden the scope and introduce many refinements in industrial electrification.

Motors

Outstanding development of the year in the motor field was a new line of fractional-horsepower motors called Form G. Considerably smaller in size and weighing as much as 51 percent less per horsepower than the models it replaces, it is the only motor of its type recommended for all-angle operation.

Major engineering advances include a new insulation of a special nylon material for use in slot and between-phase insulation and wedges. Other design "firsts" include new bearings, lubrication system, ventilation, mountings,

windings, end shields, terminal board, and leads.

The motors are available in open, drip-proof, and totally enclosed fan-cooled models in polyphase, capacitor-start, split-phase, and permanent-split capacitor types.

Three slow-speed synchronous pump motors were furnished McNary Dam in Oregon for an unusual application. The motors are rated 3000 hp each at 66 $\frac{2}{3}$ rpm and are used to pump large quantities of water into a fishway to assist the Columbia River salmon in negotiating the dam in their annual spawning trip upstream. The slow speed was required to match pump characteristics that are seldom encountered in other applications. When the installation is completed, two of the motors will be in constant operation while the third will serve as a stand-by unit. Each motor is designed to pump a *minimum* of 1-billion-400-million gallons of water in 24 hours—more than New York City uses in a similar period.

A new three-piece gear motor was developed to give industry the advantage of simplified maintenance. By the use of an adaptor ring between the gear housing and the motor, it is now possible to replace the motor stator in a matter of minutes without removing the gear motor from the load.

A development of interest to manufacturers of punch presses, centrifuges, and other high-inertia-load machines, was the new totally enclosed fan-cooled high-slip induction motor. A unique extended-bar rotor design provides the most efficient means yet developed of removing heat losses while still maintaining a total enclosure of the windings. The new motor allows space savings up to 30 percent, weight reduction up to 40 percent, and improved electrical efficiency.

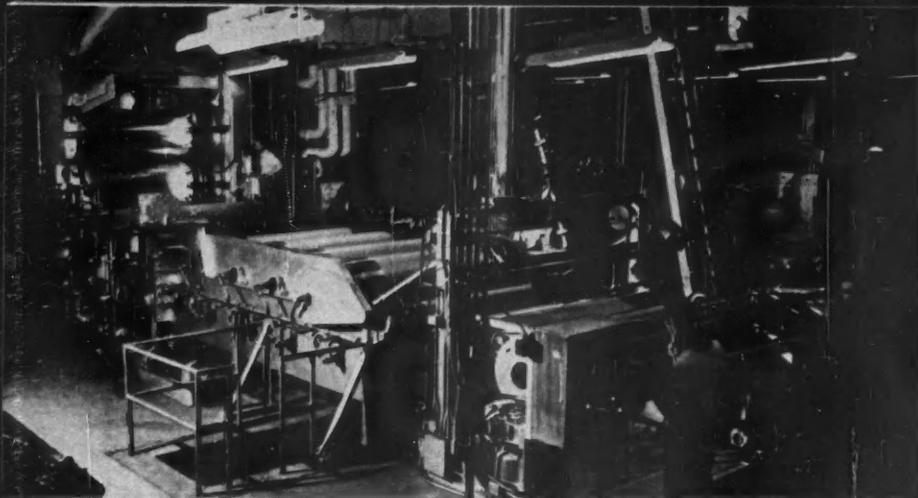
A new motor designed especially for driving boiler-feed pumps in steam generating stations offers a number of features to the central-station industry. These include cubical shape for minimum width and air-discharge out the front to prevent recirculation and personnel discomfort.

Dynamometers

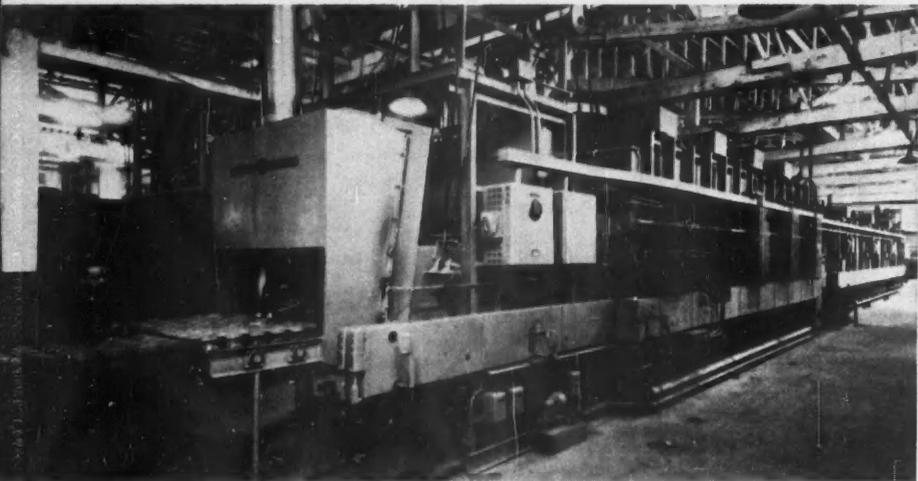
An unusual axle test stand to test large truck axles was furnished during the year to a Detroit axle firm.

A cradled d-c dynamometer provides the power input at the drive shaft, and two uncradled d-c dynamometers absorb the output at the axles through gear boxes. D-c power is provided by motor-generator sets.

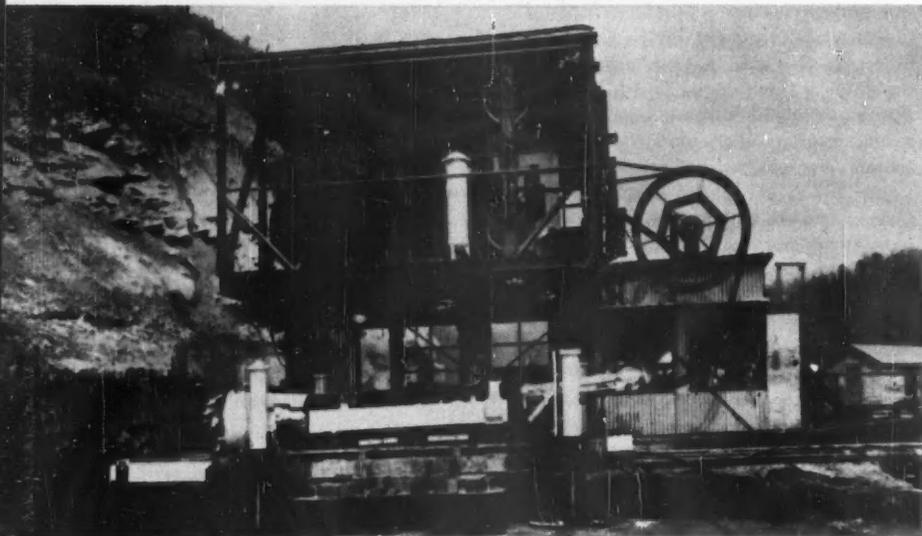
This installation is unusual in that flywheels are provided, both on the



PLASTIC FILM calender train is driven by several d-c motors. Speed of the motors can be adjusted within wide limits, but once adjusted, motors remain in step



ELECTRICALLY HEATED roller-hearth furnaces are designed to anneal from 5500 to 13,750 pounds of steel cartridge cases per hour at 1250 F



REMOTE-CONTROLLED coal digger developed for Carbide and Carbon Chemicals Company bores 700 feet into coal seam with 30-foot conveyor belt sections

input and the output dynamometers, for the purpose of providing impact loads to simulate severe road conditions. The flywheels are designed for variable inertia by adding or subtracting steel discs to the running shaft. The operator can move discs to or from the rotating shaft by hand, without need of crane facilities.

Fully automatic dynamometer control is provided by amplidyacs. This system is designed to produce speeds and torques according to a prearranged program recorded on magnetic tape. The test run may be of several hours duration, and can be repeated by rewinding the tape.

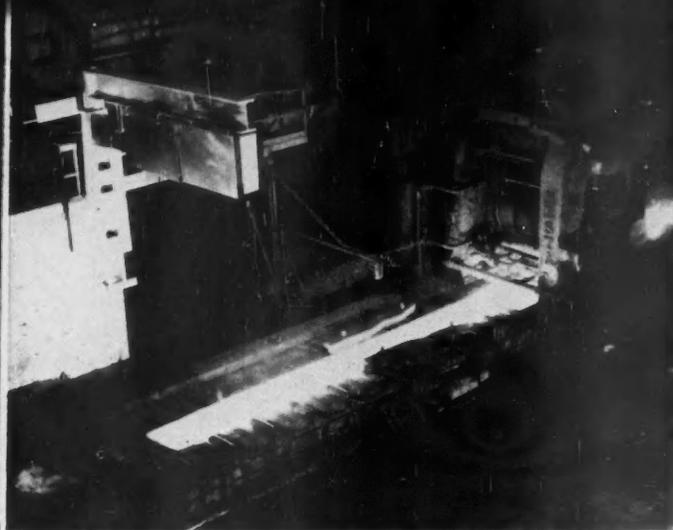
The complete equipment is designed for a maximum inertia equivalent to a 75-ton truck traveling at speeds up to 60 mph.

Control

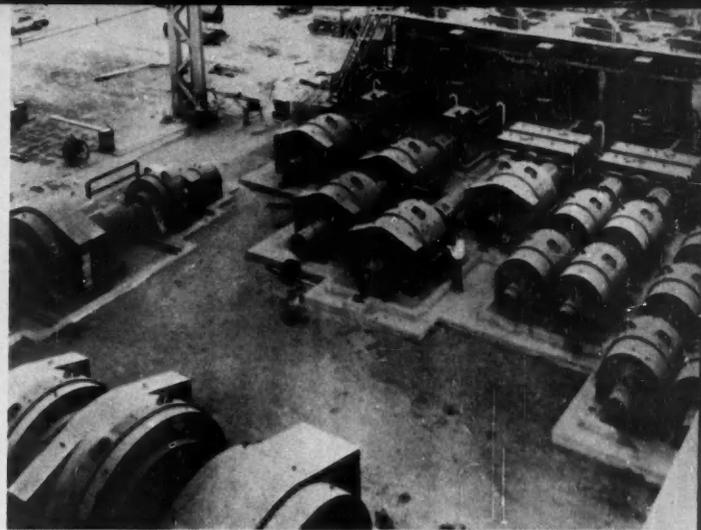
Industry has long recognized the advantage of grouping standard controllers that serve motors in a given area into common structures of standardized designs. During the year a new design of motor control center that represents a co-ordinated system of control, overload protection, and short-circuit protection of motor branch circuits was introduced. Individual starters are "stabbed" onto a bus, thus allowing easy removal for inspection and repair. Compartments are standardized and easily can be changed to a different size.

A new control panel for use with high-voltage electrostatic dust-precipitation equipment was introduced in 1952. Making use of a monocyclic constant-current network, the new control provides higher operating efficiency and better over-all utilization of available power capacity in existing or future installations.

Short circuits are the rule and not the exception in electrostatic precipitators because of the inherently unstable electrical characteristics of the load. Monocyclic control maintains essentially constant-current output regardless of changes in load impedance—from normal operating to short-circuit conditions. When a short circuit occurs—usually in the form of an arc—the network instantly limits the fault current to a low value, thus extinguishing the arc. Sustained arcing is prevented without reducing the input voltage, and normal operation returns the instant the fault is cleared. Power trip-outs are almost entirely eliminated.



WIDTH GAGE measures and records exact width of moving hot strip. Closer tolerance in rolled steel effects large savings



WORLD'S FASTEST cold-strip mill has five tandem stands and a winding reel (not shown) individually driven by d-c motors

To protect hermetically sealed integral-horsepower air-conditioning motors against injurious overloads, a new thermal relay was designed specifically for this purpose.

While running, the motor is cooled by the refrigerant. Although this permits use of a smaller motor, it also results in an allowable stalled time that is extremely short. The relay must trip about three times as fast as conventional relays. The usual strip of bimetal—heated indirectly by the motor current flowing through a small heater—is too slow for this application. And if the bimetal were to be heated directly by carrying the motor current, the response would be too fast. The new relay solves the problem by passing the motor current through heater and bimetal. By correctly proportioning their resistance, the desired speed is obtained.

For fabricating 16-inch steel tube by resistance welding, an ignitron contactor was delivered during 1952 which is six times larger than any built previously. This contactor controls 4000 kva continuously to make a "mash" seam weld.

At the other extreme, an electronic spot-welder control was supplied to control precisely the resistance welding of extremely small electron tube parts. The rating of this control is 20 amp (demand) and it is one-third the size of any previous unit.

Control Cable

Cables for supervisory control circuits, as well as telephone, police, and fire alarm, were developed with polyethylene insulation and thermoplastic

jackets. They are resistant to moisture, flame, oil, acids, alkalis, and electrolysis. They can be produced with conductor sizes 24 Awg and larger, and with insulation thicknesses as low as 0.015 inch. Complete color coding is done by the use of colored polyethylene and spiral stripes.

The ignition cable line was augmented by the development of a Grade C ignition cable meeting the requirements of Army Ordnance specifications covering insulated high-tension ignition cable for ignition systems of internal combustion engines for aircraft, automotive vehicles, and marine service.

This, like Grade B all-silicone ignition cable developed in 1951, possesses excellent electrical properties even after prolonged immersions in petroleum hydrocarbons.

Capable of operation through -65 to $+250$ F, the cable has a stainless-steel conductor with a synthetic rubber insulation, a reinforcing glass-fiber braid, and an over-all sheath of neoprene rubber.

Heating

Electrically heated roller-hearth furnaces were designed in 1952 for bright-annealing steel cartridge cases between drawing operations. To achieve uniform heating at 1250 F, high-capacity centrifugal fans are mounted in the roofs of heating chambers; baffles are mounted in the roofs and sidewalls to direct the flow of protective atmosphere gas over the sidewall and bottom heating units and through the work. Fans and baffles were also utilized in the cooling chambers to accelerate cooling and to save floor space. Controlled by electric eyes

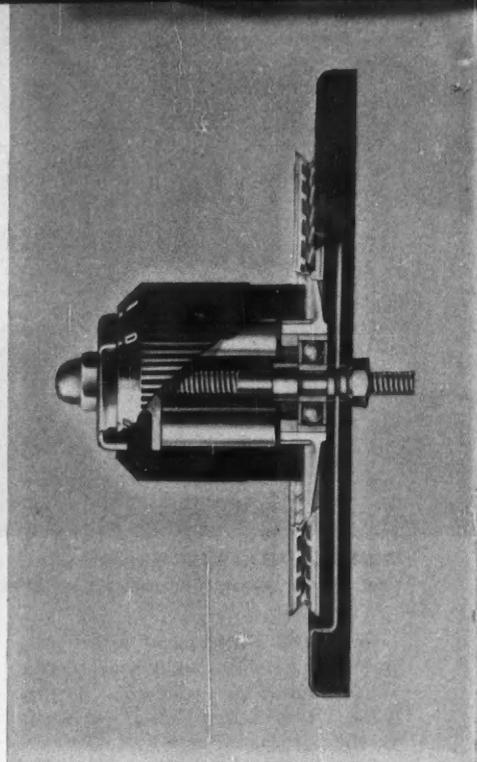
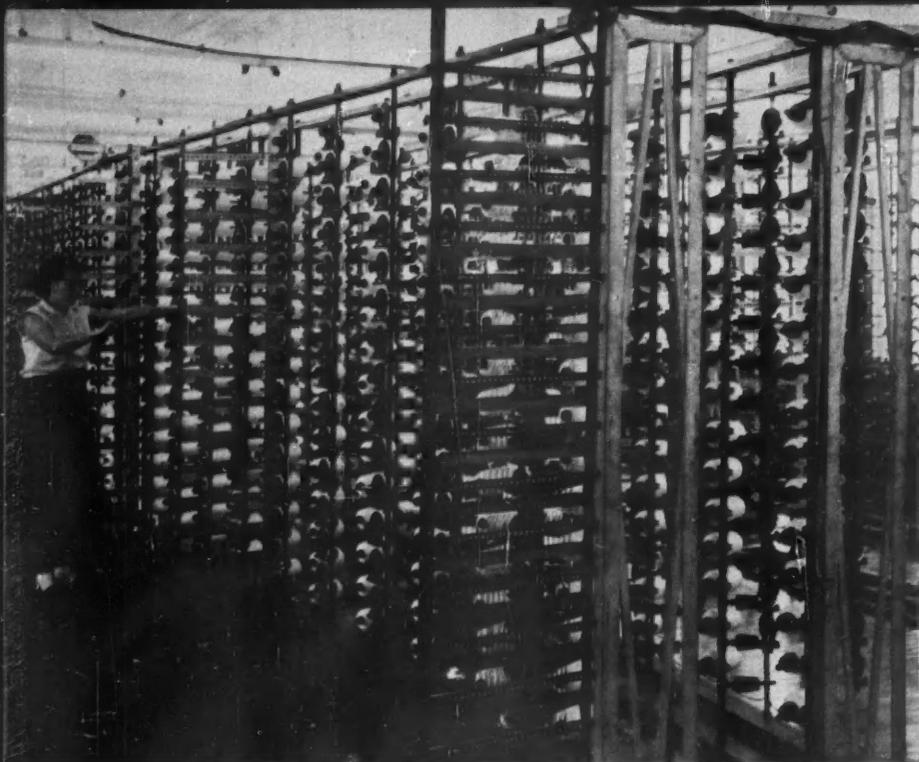
and magnetic starters, pairs of baskets are charged and discharged in three-minute cycles. Four standard furnace sizes result in a range of capacities able to anneal from 5500 to 13,750 pounds gross per hour at 1250 F.

Glow plugs reduce starting-time and cranking-power requirements of diesel engines in cold weather. Small-diameter electric resistance heaters are operated from battery power and are inserted in the precombustion chambers of each cylinder. In starting, the 1800-F high-temperature glow plugs aid fuel ignition by providing a hot surface for the initial burning of fuel.

In the production of gas-filled ignition coils a novel method was adopted to solder the ceramic high-voltage bushing to the stainless-steel end of the coil. Seals made by this method are hermetically tight and eliminate the use of any gaskets of resinous sealants. In addition, the seals are satisfactory for both high and low temperatures.

The areas to be solder-sealed are painted with a thin layer of titanium hydride, assembled with the solder, and heated under vacuum. The solder melts and flows against the painted areas after the thermal dissociation of the titanium hydride, thus forming a true metal-to-ceramic bond.

By using a ductile solder—as for example, one of high lead content—it is not necessary to use metal parts which match the ceramic for coefficient of expansion because the solder is elastic enough to relieve strains on the ceramic parts. Seals made by this method have been tested and found to be stronger than the ceramic itself.



WARPING CREEL of the magazine type is equipped with hysteresis brakes that use permanent magnets to control torque range. Thread breakage is reduced, resulting in a fabric of improved quality. Cut-away of hysteresis brake is at the right

Welding

An atomic hydrogen welder of a single rating that was developed during 1952 covers the complete welding range formerly covered by two ratings. The new welder weighs less and takes up smaller floor space than either of the two ratings it supersedes. More standard parts are used and a simplified control makes arc-starting easier than before.

Raw Materials and Mining

To satisfy the growing need for industry's raw materials many new projects were completed during the year and many more are under way. Electrification plays a major part in most of them.

For instance, the demand for aluminum was stepped up by more than 50 percent after the Korean outbreak in 1950. Electrolytic refining of this metal requires tremendous amounts of power—9 to 10 kw-hr per pound—and cheap power is imperative. The industry found that water power would not be available in the immediate future so they turned to natural gas as the next best source. Three large plants were quickly designed and built in Texas and Louisiana. Reciprocating gas engines, each driving a d-c generator, are used. (On such short notice industry could not obtain large turbine-generator units—considered to

be the most satisfactory—for generating a-c power and then rectifying it to d-c at the potlines.)

One plant has two large potlines, each requiring 82,000 kw at 725 volts d-c. Two batteries of gas engines, each rated 2500 kw or 2000 kw capacity are used. Considering the need of power for purposes other than refining, the total generating capacity at that plant is close to 190,000 kw. Another plant has a total of approximately 225,000 kw installed. The third new plant also provided the first two electrolytic potlines with engine-driven d-c generators; the six additional potlines will be equipped with rectifiers and a 300,000-kw turbine-generator plant is now under construction.

Still another attempt to obtain low-cost power for the same purpose is under way in Texas. Lignite coal will be used as fuel for a 240,000-kw steam station with rectifiers employed on the several potlines.

Many projects dealing with other industrial materials attracted engineering attention and effort during the year. Progress in the development of low-grade iron-ore deposits will require large blocks of electric power and a variety of drives for concentrating plants. The quest for more iron ore also took the form of opening large underground

mines that require mine hoists as large as 4500-hp capacity, among the largest in the world. Development of new iron-ore deposits in Venezuela will involve the building of power plants, 90 miles of railroad, and dock-loading facilities at the tidewater on the Orinoco River for shipping ore to U.S. ports.

Rapidly increasing production of chemicals—such as chlorine, sodium, phosphorus, and many others—imposes additional tasks on the electrical industry since many processes are electrochemical or electrothermal in character.

During 1952 a set of portable power and control cables was designed and built for a remotely controlled mechanical digger used in coal mines.

The power cable contains 14 power conductors and two ground wires for the operation of five separate motors; the control cable has 57 control wires for control and communication. Each cable is protected by a double reinforced geoprene jacket and has an over-all diameter of approximately 2½ inches.

Steel

The trend in steel mills—and in all manufacturing industries—is to higher speeds and a larger degree of automatic control. The goal is more production and better quality.

A five-stand tandem cold reduction mill put in service during 1952 is a good example. It rolls tin plate at 7000 feet per minute—the highest rolling speed yet achieved. At this speed the mill is capable of delivering enough steel to produce some 700,000 No. 2 tin cans every hour. A total of 21,650 hp of d-c motors is driving this mill, with each motor being supplied from a separate generator. Intricate control keeps the several motors in step during rapid deceleration and acceleration and maintains proper tension on the strip at all times.

All in all, the steel industry purchased 169,000 hp of large mill motors and 138,000 kw of large a-c and d-c motor-generator sets from General Electric in 1952. Most of this equipment is applied to main mill drives and is supplemented by additional thousands of horsepower and kilowatts of auxiliary motors and motor-generator sets.

To supply cold reduction mills with hot-rolled strip of proper gage and width, it is necessary to equip the hot mills with proper gaging devices.

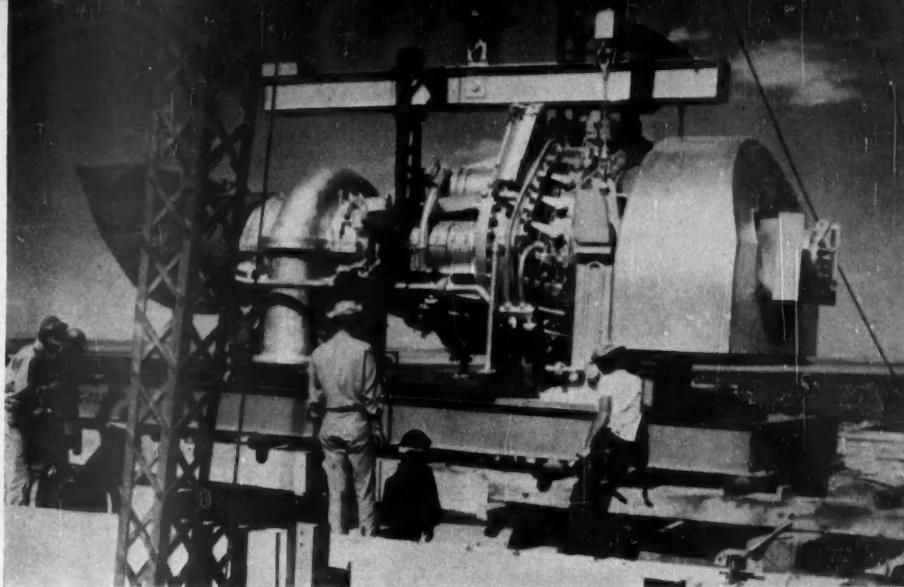
For many years hot mills have been equipped with 100-kv x-ray gages that keep track of strip thickness. During 1952 another tool, a width gage, was put into service. It is a noncontacting device that continually and automatically measures the width of hot-strip steel to an accuracy of one-eighth inch.

Two phototube scanners mounted 15 feet above the hot steel pick up the light radiated from the strip and convert it into electrical signals. The resulting signals are amplified, and used to determine the width and deviation from the chosen gage setting.

Strip width of 10 to 96 inches can be measured at temperatures of 1350 to 2050 F and indicated in less than one second after the strip passes under the detector. Strip position can change as much as three inches either vertically or horizontally without affecting the gage accuracy.

With this gage, operators should be able to hold width much closer to the desired value and thus reduce waste. For a mill rolling one million tons of steel per year, a reduction in width of only one-eighth inch would convert 4000 tons of steel per year from scrap to finished steel at a savings of over \$100,000.

Several amplidyne control equipments were furnished for blast-furnace skip hoists. The equipments include auto-



GAS TURBINE in the process of being installed in a Southwest compressor station will pump natural gas to industrial centers throughout the country

matic programming control of the distributor and the furnace bells. Dumping programs are present on a bank of push buttons, and a system of telephone-type relays set up the sequence circuits for various dumping cycles, depending on the materials to be fed into the furnace.

Manufacturing Industries

Other industries are also keeping pace with steel by increasing their processing speeds.

The fastest paper-making machine recently installed produces 25,000 miles of tissue paper every 24 hours—more than enough to encircle the world. Handling such thin tissue at high speed is no mean problem. High-accuracy electronic amplidyne regulators are used to maintain machine speed within extremely narrow limits.

In the same field a new system of tension control was developed for paper-mill supercalenders. A motor-operated rheostat changes the strength of the d-c motor field as a function of reel diameter. The pilot motor of the rheostat receives its power from an amplistat which acts as a current regulator and causes the rheostat to strengthen the motor field as the roll diameter increases.

Simultaneously, an auxiliary field on the generator regulator amplidyne causes a reduction in generator voltage, thereby maintaining constant tension through constant horsepower. Field testing proved that the new control system is superior to previously used systems, especially in the region of low motor speeds and low tension.

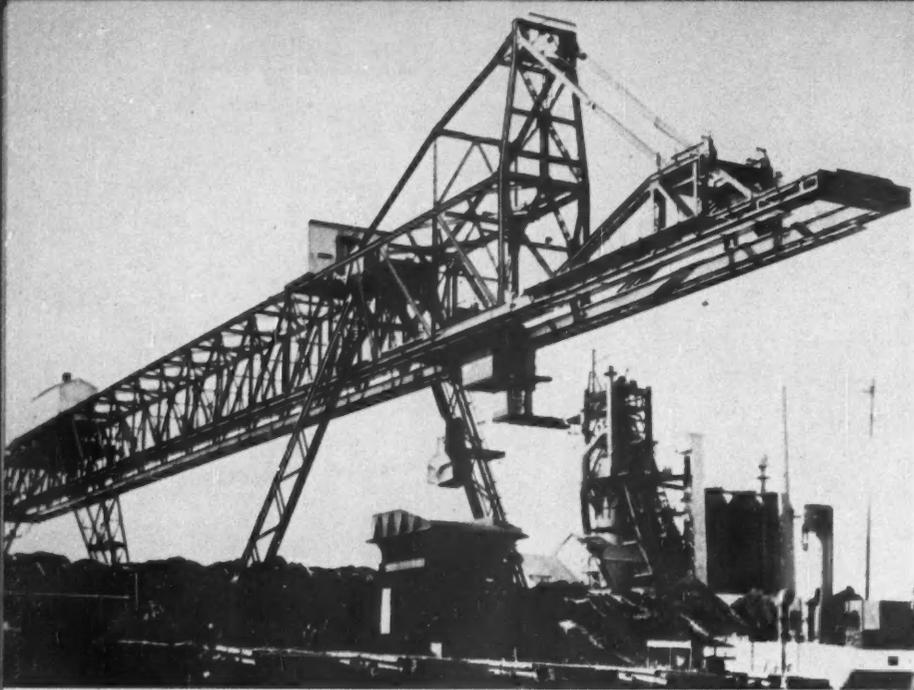
The longest motor-generator set built by General Electric was shipped during the year. It was furnished for a multiple-generator electronic-amplidyne-controlled sectional paper-machine drive. The paper machine is a 270-inch wide Fourdrinier machine with antifricition bearings throughout. It will produce 47- to 100-pound board (on a 1000-square-foot basis) at a rate of 300 to 1500 feet per minute. In other words, the material will weigh from three-fourths to 1.6 ounce per square foot and is a material similar to manila business-file folders, 15 to 30 mils thick.

The motor-generator set has 14 units and 28 sleeve bearings. All units have two bearings and are directly connected to each other and to the driving motor by flexible couplings. The unit is more than 82 feet long and is mounted on four base sections.

Synthetic fibers are steadily increasing their foothold in the textile field.

Compared with conventional textile mills, their production requires radically new electric equipment. In one installation a large number of small fractional-horsepower synchronous spinning motors are supplied from a source of adjustable frequency that determines the speed of the spinning operation. To obtain high quality yarn and accurate yarn gage, the frequency, and therefore the spinning speed, must be maintained to an accuracy of ± 0.1 percent over a speed range of an 8 to 1 ratio.

A new screenless open textile motor was developed for operation in lint-laden atmospheres. Its simplified ventilation



ORE BRIDGE of 12-ton capacity is equipped with adjustable voltage d-c drives and is supplied with a-c power. Ore from boat is being unloaded into hopper

system provides both effective cooling and positive lint expulsion. Lint-filled air enters both end shields through large intake openings and is discharged through openings farther out in the same end shield. Cooling fans, shaped to shed lint, force air and lint over end-windings and then back out of the motor. Coil end-turns are filled with a special compound that provides a smooth finish and helps provide accumulation of lint.

A line of permanent-magnet hysteresis brakes covering a torque range of 0.15 to 250 ounce-inches was developed. The smallest size—designed specifically for the control of the tension of yarns or threads during certain operations in the textile industry—includes a plastic pulley over which the yarn is passed while hysteresis forces resist pulley rotation. The pulley—mounted on a ball bearing—carries a ring of magnetic material rotating in the field of a pair of permanent magnets. The material in the ring is thus subjected to a magnetomotive force which drives the ring through its hysteresis loop and results in a torque that is smooth, continuous, and substantially constant with speed. Desired tension is obtained by varying the air gap in the magnetic circuit.

During the year the Trumbull Department of General Electric supplied the answer to a major problem in the textile industry—fire hazard—when it introduced a loom switch with a new

lint-tight enclosure. The switch can be mounted for connection from above or below.

In the machine-tool industry electric equipment permitted carrying out several novel developments. For instance, to operate a machine tool at optimum efficiency, it is highly desirable to maintain maximum permissible cutting speed. If the work is of variable diameter, the rotating speed and the "feed" should be adjusted inversely with the diameter. This is done automatically by employing an adjustable speed drive and an electronic amplidyne tracer control for forming the necessary profile of the work.

Present expansion of aircraft production is also materially assisted by recently developed tracer controls for automatically milling the aircraft "skins" out of one-piece aluminum sheets. Such milling machines are now in quantity production.

The continuing trend in industry is toward adjustable speed d-c drives. These drives are often provided with spot conversion—the available a-c power is converted to d-c for each motor or for each group of motors driving a processing unit. The converting unit frequently takes the shape of a motor-generator, permitting extremely flexible speed control by generator voltage, as well as by motor field control. The resultant wide speed range and availability of regenerative braking makes this system attrac-

tive. It has been successfully applied in ever-increasing numbers to continuous processes used in making paper, steel, rubber, textiles, and in many other industries.

This generator-voltage control system is also taking a firmer hold in the heavy materials-handling applications. An increasing number of these drives are being built for coal and ore bridges and unloaders, cargo winches, various conveyors, and similar applications.

For certain applications an electronic rectifier serves as a most suitable spot-converting unit, particularly when reversing or regeneration is not required, or when a static rather than a rotating converter is preferred. Such electronic d-c drives are applied in all sizes, from fractional-horsepower units on blue-printing machines, to 5000-hp steel-mill drives. This type of drive for newspaper and magazine presses has been widely adopted by the printing industry.

The modern concept of high-voltage power distribution in an industrial plant with step-down transformation at load centers is now almost universally recognized. This system is exclusively used in new plants, and old plants are also adopting it whenever they are undergoing modernization.

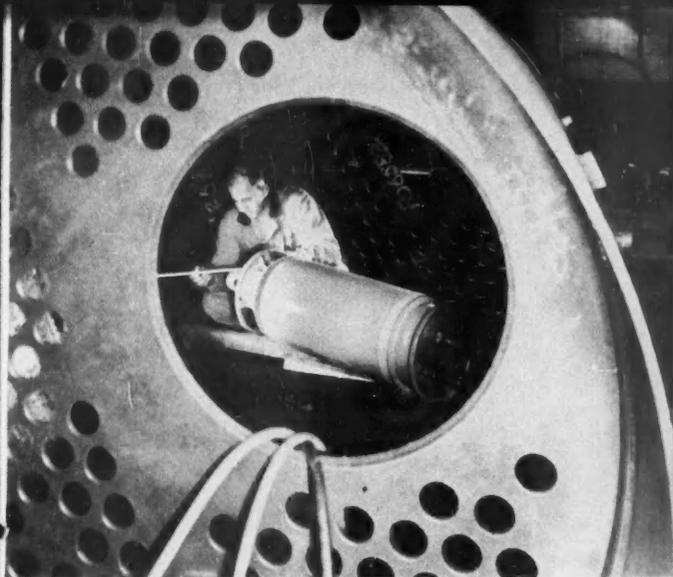
The present trend is to ground the neutral of low-voltage industrial power systems, thereby gaining the same advantages as were recognized for systems of higher voltages (2300 to 13,800 volts); namely, prevention of over-voltages, better isolation, and easier location of faults.

With 480/277-volt grounded-neutral systems, it is economical to use the same transformers for both the motors and the fluorescent lighting. This method is being adopted for many modern industrial plants, large office buildings, and public buildings.

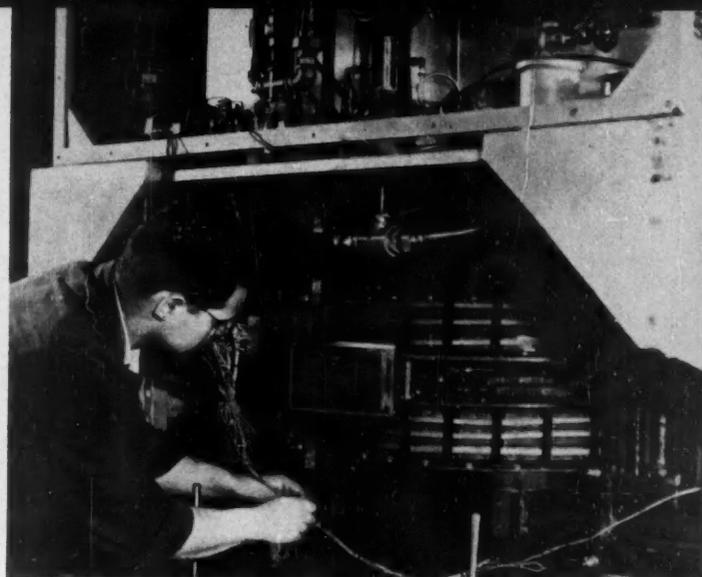
During the year the Trumbull Department of General Electric redesigned its low-voltage busway system and used aluminum bus bars at a 25 to 35 percent weight saving over its copper counterpart. Simple adapters allow the aluminum bus to tie into existing copper systems.

Materials Handling

A new tool, the combustion gas turbine, is gaining a firm foothold in industry. It is proving to be an ideal drive for compressor stations pumping natural gas from the Southwest to



PORTABLE 250-KV X-RAY UNIT weighing only 150 pounds is brought inside a pressure vessel to x-ray welds



INDUSTRIAL BETATRON x-rays armor plate of tanks. Suspended from overhead crane, the unit has freedom in testing area

many industrial centers in the Midwest, Northeast, and Pacific Coast. Gas turbines are also being used for repressurizing oil fields. More than 50 units rated 5000-hp each have been ordered for these applications and several are already in service.

Because the gas turbine with its auxiliaries represents a rather involved system that requires a carefully laid-out sequence during starting or stopping, a good control system is imperative. A new system was developed in 1952, the heart of which is a sequence timer that initiates the starting and stopping of the various auxiliaries as a function of time and turbine speed.

X-ray

A portable high-power x-ray machine that packs a 250,000-volt wallop was announced in 1952. Less than 15 inches in diameter and 44 inches long, the unit is 56 percent smaller in size than the conventional 250,000-volt x-ray machine. Its weight is only one-eighth that of the conventional apparatus—only 150 pounds as compared to 1150 pounds. And as a result, the x-ray unit can be brought to the product, instead of bringing the product to the unit.

Capable of inspecting $3\frac{1}{2}$ inches of steel, the new unit can be used in welding shops or foundries. Or it can be carried on location for such projects as ship, dam, and power-plant building; testing oil-refinery cracking towers; laying pipe lines; bridge construction; and any other construction work where the soundness of welded seams is

vital to economical trouble-free operation and safety. Secret of the size and weight reduction is the use of a high-frequency resonant transformer instead of the closed iron-core type ordinarily used. Another contributing factor is the use of gas insulation instead of heavy oil.

First unit of its kind in the automotive industry, an industrial betatron operating at from 5 to 15 million volts was delivered to a large automobile company in 1952. The unit will be used to inspect big steel sections of medium tanks for the Armed Services. Its sensitivity for the detection of flaws increases as the thickness of the steel increases. On a 14-inch thickness it will detect a void 0.042 inches in cross section.

A large number of x-ray units were built to check automatically the level of the powder in hand grenade fuses, and to reject those below the acceptable level. The unit is so devised that its circuit retests itself regularly to insure that a defective fuse will never pass. Any faulty operation results in all fuses being rejected, and this signals the operator. The automatic method does the whole job at the rate of 28 fuses per minute.

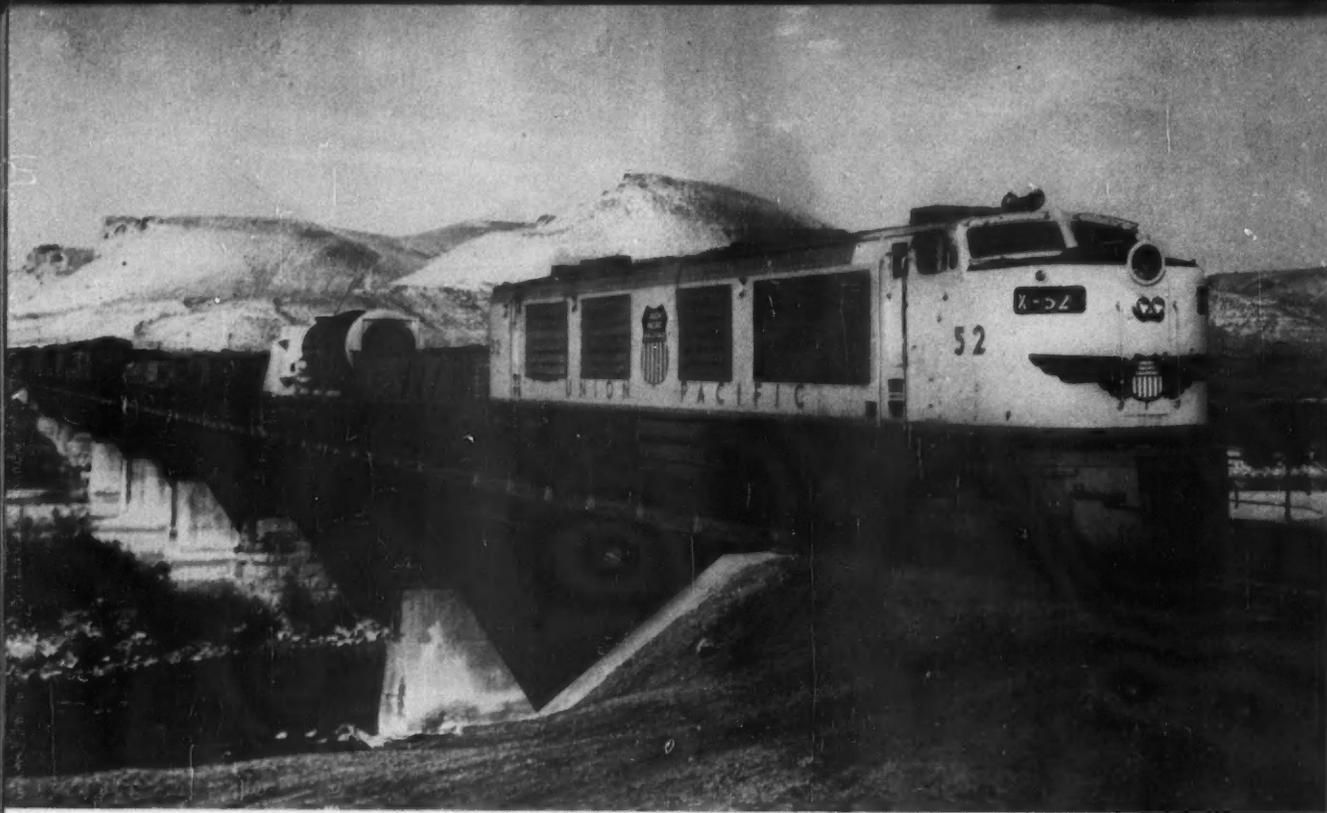
An x-ray machine was designed for inspection and process control of grain, and for observing the degree of checking in grain, corn germination and effectiveness of fumigation on infestation. Heart of the new unit is a beryllium-window x-ray tube. It allows the transmission of long-wave less-penetrating radiation required to examine low-density material, such as grain.

Until the development of the beryllium window in x-ray tubes, an x-ray grain-inspection unit was impracticable.

The first of an order of 20 units for inspecting military footwear was delivered during the year. Fluoroscopy will reveal hidden defects in footwear that affect serviceability. Former inspection necessitated either tedious examination or destroying the footwear—now it can be done nondestructively.

An x-ray diffraction unit is being used to find a better quality lower-cost concrete. One valuable characteristic of the apparatus is that small samples weighing only a few hundred-thousandths of an ounce are used to obtain the diffraction data.

Semiautomatic x-ray equipment, installed recently for a large aircraft manufacturer, boosts speed of inspecting vital castings 200 percent. In cooperation with the manufacturer, General Electric laid out a new department around its 140-kv semiautomatic radiography unit and a special machine for film processing. A feature of the 140-kv unit is automatic door closing of a lead-lined cabinet with preset exposure timing. Work is pushed into the cabinet on trays already set up over rollers. Setup is a continuous process because radiation protection by the lead-lined cabinet permits all personnel to continue working nearby. Results of the new installation are elimination of a second-shift operation of about 80 man-hours per week, and an increased tube time of about 100 percent per eight-hour shift.



FIRST PRODUCTION UNITS OF A 4500-HP GAS-TURBINE ELECTRIC LOCOMOTIVE SAW HEAVY-DUTY FREIGHT SERVICE DURING 1952

Rail

Six production units of a 4500-hp gas turbine electric locomotive were delivered to the Union Pacific Railroad in 1952. These differed slightly from the pilot model that saw more than 100,000 miles of service operation. No basic changes were made in the production units, but minor modifications were carried out to improve operation and servicing. For instance, the fuel tanks were made easier to fill and gage, and their capacity was increased. The main turbine-generator units were manufactured and installed so that they can be removed and replaced or interchanged between locomotives without preliminary shimming or line-up. The power-plant starting was simplified and made semiautomatic.

Locomotive Development Center

Full-scale testing of locomotives under simulated operating conditions will be possible on a dynamometer that is now under construction. Facts can thus

be gathered concerning application data on wheel slip, allowable adhesion, and high-speed locomotive dynamics. In addition, a locomotive test track will be modified to incorporate known errors to assist in developing high-speed trucks.

Diesel-electric Locomotives

During the year the maximum capacity of dynamic braking on the Alco-GE line of diesel-electric locomotives was increased. The new control system automatically compensates for train speed and gives maximum braking capacity available for any braking notch the engineman may select.

A new "hump" controller for Alco-GE switchers and road locomotives was developed for use where precision control of tractive effort is necessary. This controller is useful in hump service and for starting heavy trains under slippery track conditions where the torque necessary to move the train otherwise would almost slip the wheels.

Army Locomotives

During the year deliveries were begun on 83 diesel-electric road switchers rated 1600 hp and capable of operating under severe climatic conditions on standard and wide-gage railroads throughout the world. They will operate at temperatures from -40 to 125 F.

Export Locomotives

A new standard 1600-hp diesel-electric freight-passenger locomotive meets the clearance and the axle-loading limits imposed by many foreign railroads. Its trucks, equipped with a new traction motor designed especially for this purpose, give high tractive effort and smooth riding at high speeds, with special adaptability for rough roadbeds.

A great variety of diesel-electric locomotives under construction for export includes an unusual design to meet conditions in Indonesia. The axle load is limited to 12 metric tons, but pro-



DIESEL-ELECTRIC ROAD SWITCHERS FOR THE ARMY CAN OPERATE ON STANDARD- AND WIDE-GAGE RAILROADS THROUGHOUT THE WORLD

vision was made for future load increase, following roadbed improvement. To meet this requirement the locomotives were designed with two regular three-axle motor trucks and a two-axle non-motored truck between them. The middle truck can be removed when increased loads go into effect. Then the entire weight of the locomotive will be utilized for traction.

Testing Lubrication Oil

The spectrograph was developed as a maintenance tool during the year to determine the quantity of key elements in samples of diesel-engine lubricating oil. Analysis of the oil indicates the condition of principal engine components without the need for physical examination or disassembly of the engine. The evaluation program extended for 10 months and involved the analysis of 12,000 samples removed from more than 1500 Alco-GE locomotives in all types of service on 22 co-operating railroads.

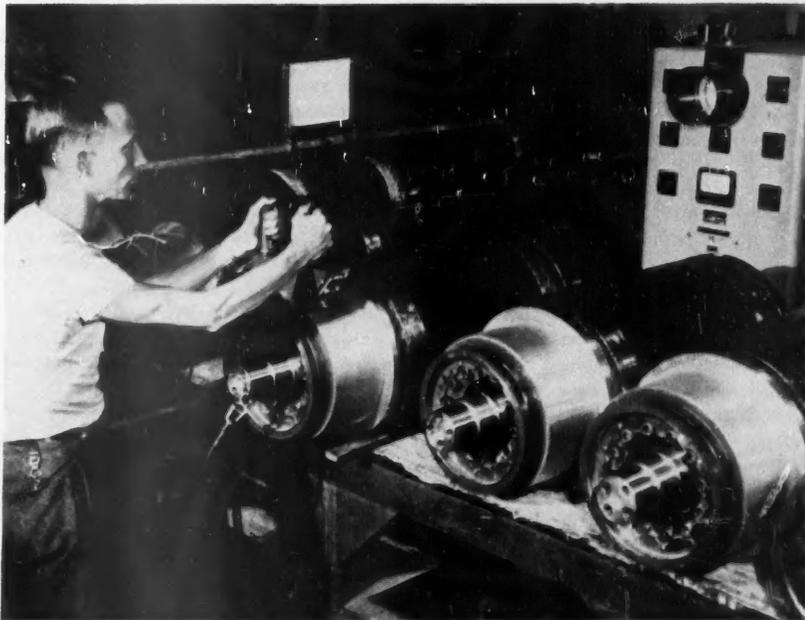
Power Plants for Hospital Cars

What is probably the largest single order for undercar power plants was completed. This covered 126 units for 63 U. S. Army hospital cars, the first of which are undergoing field tests.

Basically similar to the units on General Electric's "More Power to America Special" exhibit train that toured the United States in 1950-51, these plants are each rated 30 kw, three-phase, 60 cycles.

Other Developments

To answer the need for better wheel-slip protection of diesel-electric and electric locomotives, a new wheel slip-slide protective system was developed



WINDING INSULATION TESTER IS USED ON TRANSPORTATION MOTOR PRODUCTION LINE



AXLE-DRIVEN ALTERNATOR (ARROW) FURNISHES POWER FOR CABOOSE EQUIPMENT

Marine

The high-speed "Mariner" class of vessels being built for the Maritime Administration are the first large dry-cargo vessels equipped with a-c auxiliary power. During 1952 a group control was designed for these vessels that resulted in a radical change in the entire concept of grouping controllers.

Each group consists of an assembly of free-standing self-supporting steel cubicles. Each cubicle contains one or more individual controller compartments, and each compartment is provided with an individual front door that gives access only to that particular compartment.

All bus and controller wiring connections are completed in the factory so that the shipbuilder has only to bring power into the bus and hook on the cables running to the motors or other circuits at a distance from the group control. This group control raised the safety level above that of earlier types, eliminated the shipbuilders' headache of ordering countless types and sizes of conduit fittings, reduced installation time, and resulted in a much neater job than that obtained with individual controllers.

Cargo Winches

In addition to group control, 600 Maxspeed cargo winches were supplied for Mariner class vessels.

The inherent characteristics of high light-line speeds and low heavy-line speeds in the hoisting and lowering

directions make this system ideal for certain cargo winch operations.

Minesweepers

During the year several variations of magnetic minesweeping electrical systems were furnished to the U. S. Navy.

These included amplidyne exciter sets, controllers, panels, switchboards, switches, and generators—some driven by diesel engines, others by gas turbines—to furnish the necessary power to sweep magnetic mines.

Also furnished were generators, static exciters, and static voltage regulators and switchboards for acoustic minesweeping service.

All equipment furnished for minesweeping service is especially constructed to meet the service requirements of the application—nonmagnetic materials are used in place of magnetic materials wherever such substitution is feasible. The extensive use of nonmagnetic materials required that special tools and manufacturing techniques be developed to properly work the material.

Gear-propulsion Unit

A cross-compound turbine-gear propulsion unit with a normal rating of 8500 shaft horsepower is now on order for a single-screw Great Lakes ore carrier. Normal steam conditions are from 450 psig, 750 F, to a vacuum of one-inch Hg absolute.

The turbine design is unusual in that the astern turbine is located in the

that makes a direct comparison between axle speeds. If slipping or sliding is not corrected by ordinary means within 15 seconds, power is removed and an alarm alerts the engineman.

Turn-to-turn insulation failures have ceased to be a factor in final test and inspection of transportation motor manufacture. Applying the winding insulation tester to the production line in the early stages of manufacture has improved quality.

An axle-driven alternator designed to furnish power for operation of communication equipment and other electrical devices on cabooses and similar rolling stock was developed.

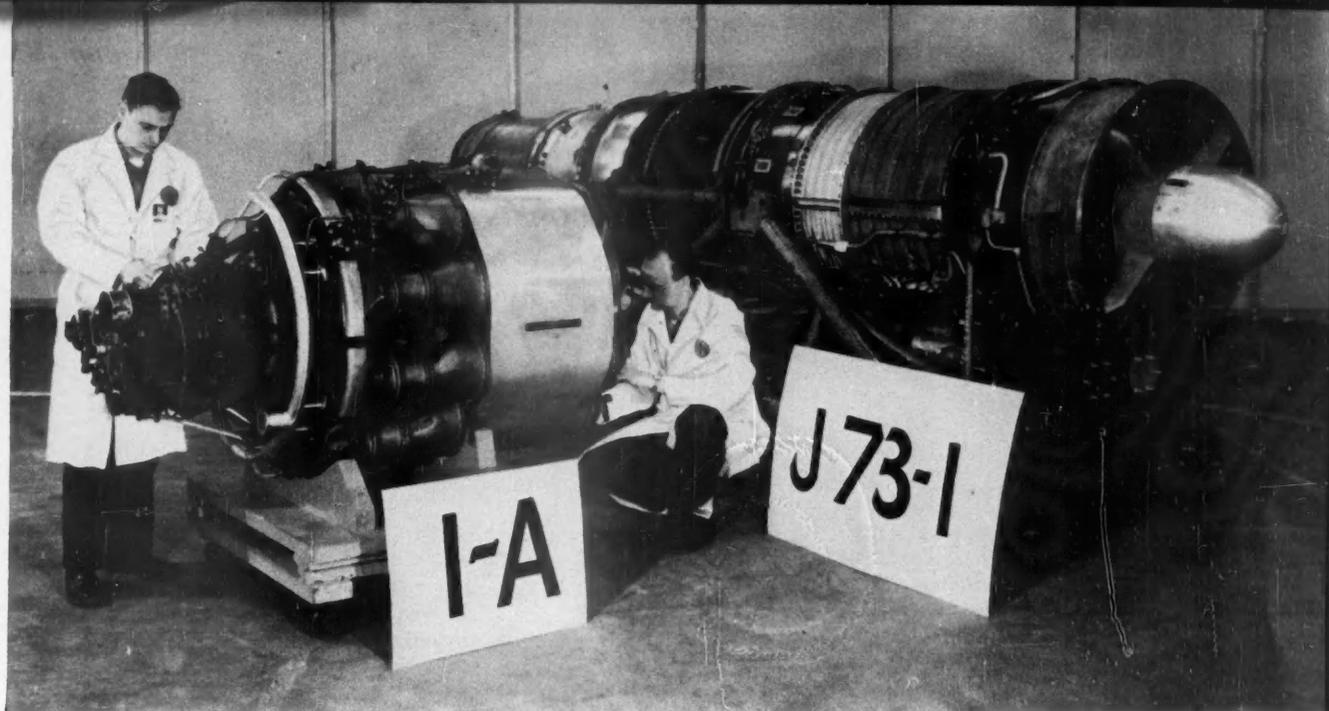
forward end of the high-pressure turbine adjacent to the first-stage wheel. Conventional location of the astern unit is usually in the exhaust casing of the low-pressure turbine. This arrangement greatly simplifies the engine-room steam piping and the turbine-control valving. It also limits the admission of high-temperature steam to one area instead of the two areas required in normal design. During ahead operation the astern turbine will be operating in a vacuum.

Equipment for Dredge

Electric equipment for one of the world's largest dredges was furnished during 1952. It will operate on a canal between Lakes St. Francis and St. Louise near Montreal, Canada. Included was a 1000-hp d-c motor with many unusual design features that will drive the cutter blades of the dredge. The motor is enclosed, has antifricition bearings, and will operate with the shaft inclined at any angle from the horizontal to 45 degrees from the horizontal.

Air Circuit Breakers

A new line of air circuit breakers to control the power flow of the electrical system on the liner *United States* has interrupting ratings of 100,000 amp in 1600- and 2500-amp continuous-rating frame sizes. This contrasts with 50,000- and 75,000-amp interrupting ratings for the comparable frame sizes of commercial breakers.



TEN-YEAR SPREAD—LATEST J-73 TURBOJET DELIVERS MANY TIMES THE THRUST OF THE I-A BUILT BY GENERAL ELECTRIC IN 1942

Aviation

"The Fastest Ten Years in History" was commemorated in March 1952, when General Electric dedicated its new aircraft gas turbine facilities at Evidale, Ohio, north of Cincinnati. It was just 10 years ago last March that America's first jet engine was successfully tested at a G-E plant in Lynn, Mass.

Jet Engines

During 1952 two engines of the famed J-47 series were announced as the first all-weather axial-flow turbojets. They are now in full production for the Boeing B-47B six-jet bomber. Another engine of the series is being delivered for use in the Navy's North American FJ-2 *Fury* fighter, while yet another will be used in the North American F-86E, an advanced version of the *Sabrejet*.

The first jet engine to have an afterburner with an all-electronic control accumulated extensive time in flight operations and was well-established in production. This engine powers the North American F-86D interceptor.

Notable progress was made toward completing the development of the J-73,

the most powerful General Electric jet engine ordered by the Air Force on a production basis. Although it has the same frame size as the J-47, it is so much more powerful—and has a lower rate of fuel consumption per pound of thrust—that engineers say it isn't even in the same class! This improved performance is the result of higher flow of air per unit frontal area, a higher cycle pressure ratio, and excellent turbine efficiency.

Production Techniques

Changes were made that will result in substantially reduced use of critical materials—columbium, tungsten, cobalt, chromium, and nickel—vital to engine construction.

Another stride forward was the beginning of production of fabricated stator blades for the turbojet compressor. This technique not only will result in substantial cost reduction, but also will release an appreciable amount of critical forging capacity to make other parts.

Another new development was the curvic coupling compressor rotor that

allows the bolting of compressor discs together rather than shrinking the discs onto a shaft.

One significant application of automatic welding methods was in the manufacture of heavy rotating parts consisting of dissimilar metals. Automatic submerged arc welding methods have reduced actual weld time from more than eight hours to 32 minutes. Automatic inert-gas-shielded arc welding methods for sheet-metal parts have resulted in further time savings.

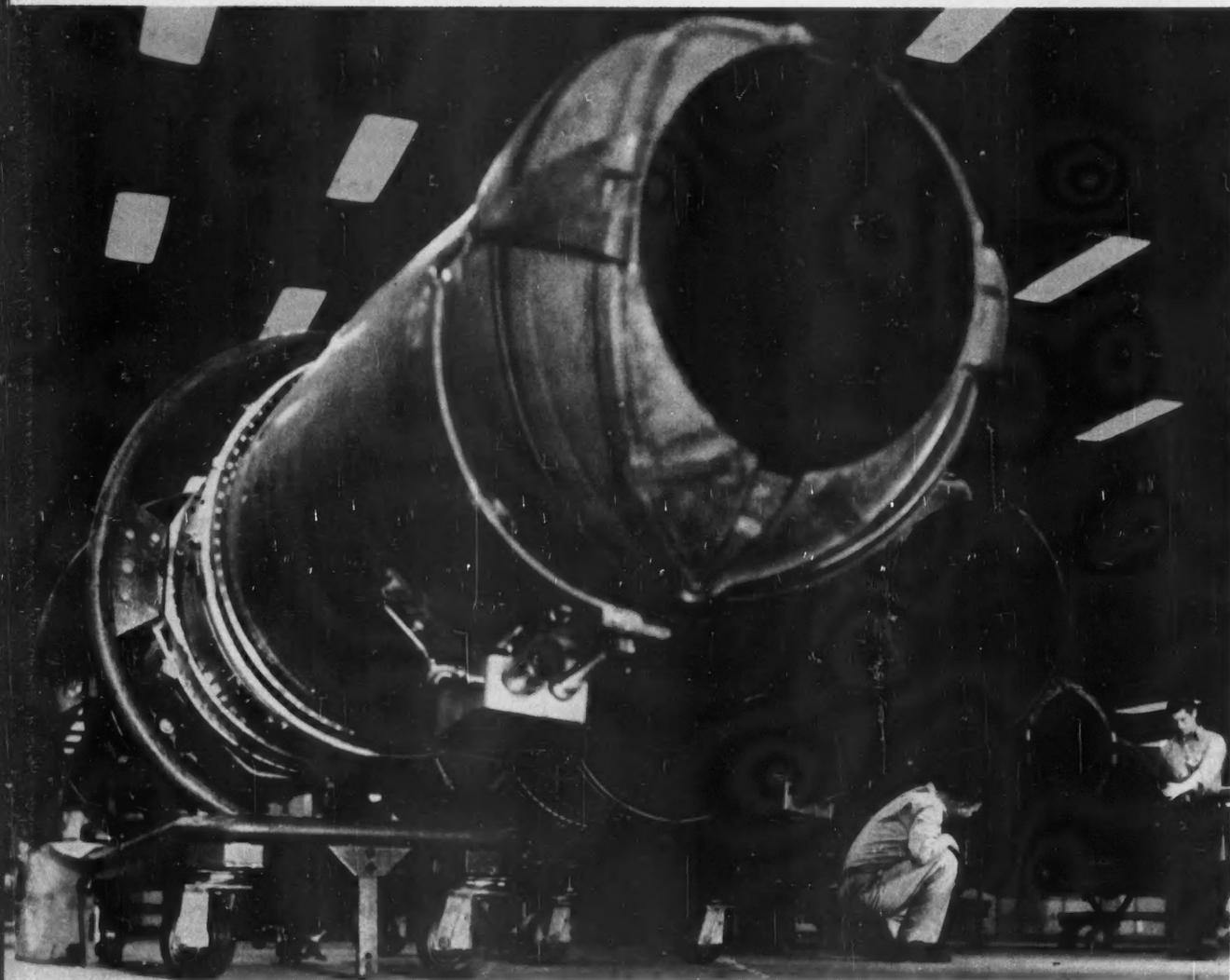
Vertical assembly of jet engines is now common practice. Standing the engines on end—rather than assembling them in a horizontal position—eliminates any possibility of sag.

Starters

Small gas turbines for starting big gas turbines and jet engines are now available. The starter, completely self-contained and consisting of a small gas turbine, torque-equalized reduction gear, and self-synchronizing clutch, is attached to the engine. This makes turn-over possible without the need for ground power units, an invaluable fea-



NORTH AMERICAN'S F-86D ROCKET-ARMED ALL-WEATHER INTERCEPTOR HAS ADDITIONAL POWER FOR FASTER CLIMB BECAUSE OF ..



... THESE GENERAL ELECTRIC TURBOJET ENGINES WITH AFTERBURNERS WHERE ADDITIONAL FUEL IS BURNED FOR THRUST AUGMENTATION

ture for aircraft operating from advanced bases.

Air-turbine Drive

Requirements for auxiliary power continued to mount during the year but a new method was introduced to take care of the increasing load. Known as an air-turbine drive, this method utilizes air bled from a jet engine compressor to drive a small, remotely located turbine which in turn powers an alternator or hydraulic pump. In the airplane the air-turbine drives can be located near their specific load applications. Other desirable factors include use of larger generators than could be mounted on the engine, excellent speed regulation, and greater design flexibility than allowed by previous methods of producing auxiliary power. Drives for 400-cycle alternators up to 60 kva and for hydraulic pumps are in production.

Aircraft Electrical Systems

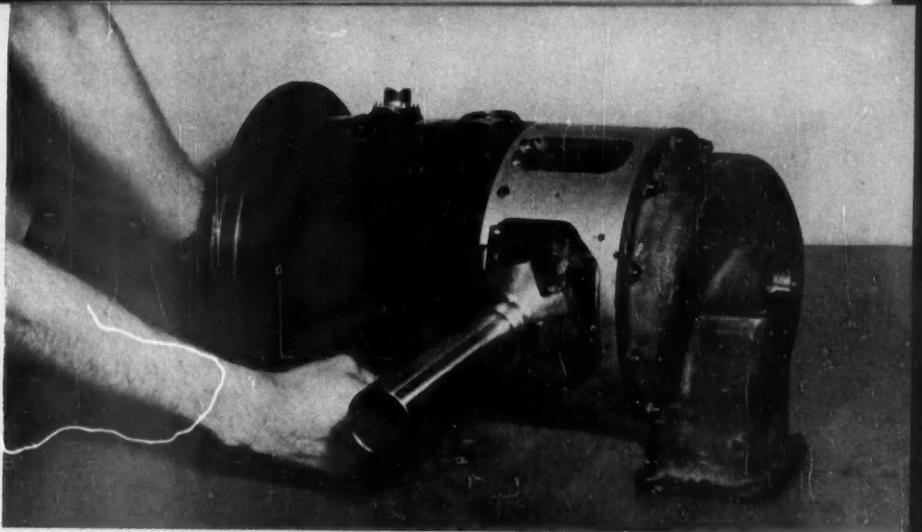
The principal advance during 1952 in aircraft electrical systems was in the application of a-c power to a number of new aircraft.

Integrated control panels were developed to provide exciter ceiling, over-voltage, differential, and underfrequency protection for a new line of three-phase a-c generators and static (magnetic amplifier) voltage regulators. The increased use of alternating current—both constant-frequency 400 cycles and variable-frequency 380 to 1000 cycles—is the result of increased demands for a-c power. A-c systems are needed for successful development of necessary components to provide co-ordinated and reliable systems. Further developments, such as selective overvoltage protection for parallel systems, are in progress.

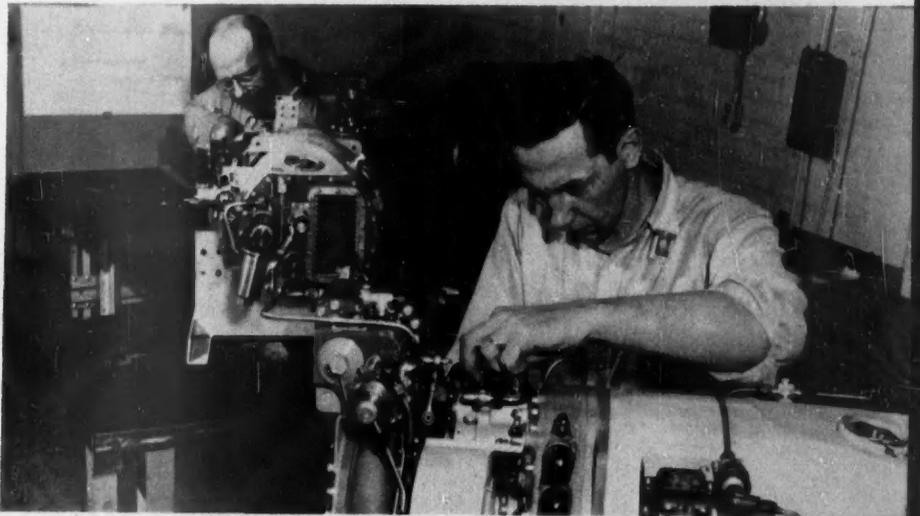
Control for Human Centrifuge

Through experimentation with a large human centrifuge, a medical laboratory of the Armed Services expects to advance its knowledge of the physiological effects of high-speed flight on jet aircraft pilots. Gimbal control equipment developed by General Electric is an integral part of this equipment.

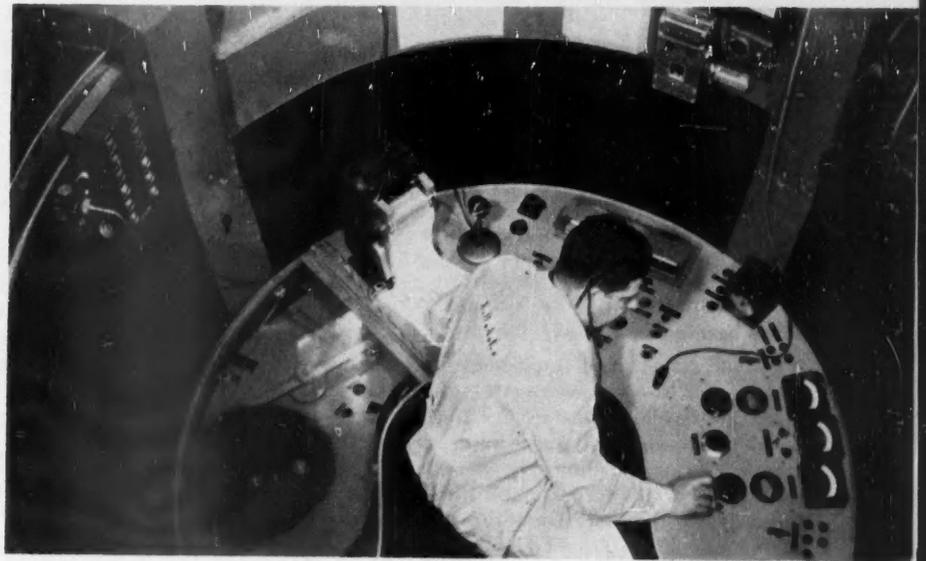
The centrifuge consists of a man-carrying gondola mounted on the end of a large rotating arm so that a subject can be oriented with respect to the acceleration force created by centrifuge rotation.



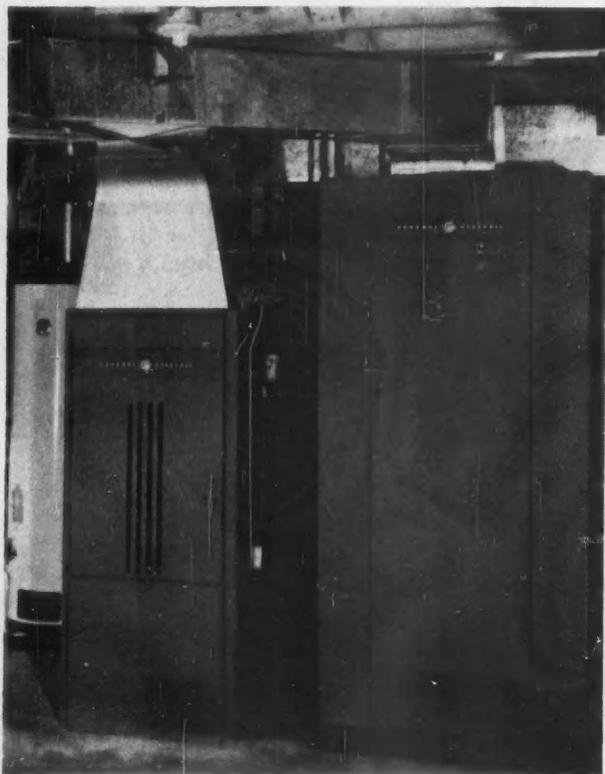
GAS TURBINE STARTER FOR TURBOJET ENGINES IS A SELF-CONTAINED GAS TURBINE



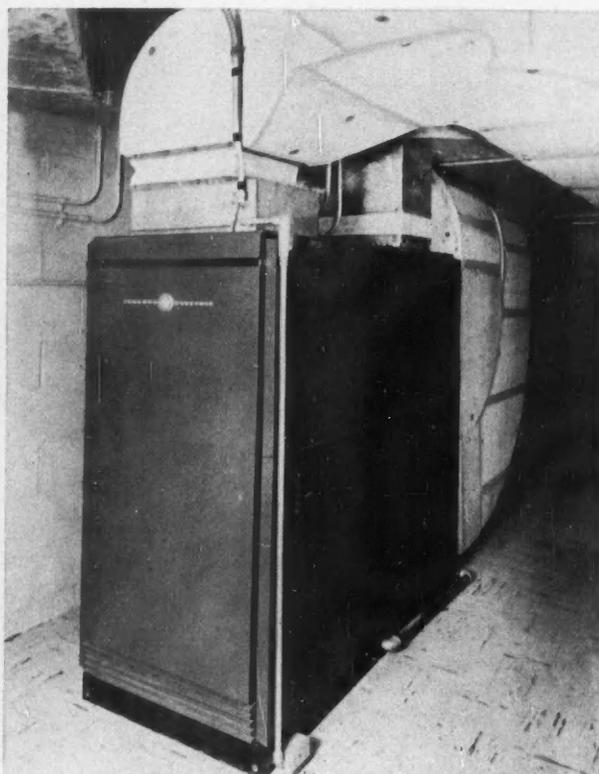
AIR TURBINES DRIVE HYDRAULIC PUMPS (ABOVE) AND OTHER AIRCRAFT ACCESSORIES



HUMAN CENTRIFUGE IS CONTROLLED FROM THIS SMALL CONTROL "BLISTER"



YEAR-ROUND air conditioning in the home is provided by the gas-fired furnace (left) and packaged residential air conditioner. Many builders include them as a standard feature



HEAT PUMP advantages for the home include fully automatic heating and cooling in one package, no fuel or chimney requirements, and uniform year-round temperature

Air Conditioning

The year 1952 was highlighted by intensified consumer interest in complete summer-cooling of the home. A number of progressive home builders from all over the country included year-round air conditioning in their standard home features. In anticipation of this demand, a line of two- and three-ton home-cooling units was placed on the market.

Home Heating

The increasing trend throughout the country for basementless houses produced an expanding market for horizontal- and down-flow types of warm-air furnaces. To meet it a line of horizontal- and down-flow gas furnaces was introduced during the year. These furnaces incorporate all the proved components of the standard gas-furnace line, as well

as the new General Electric co-ordinated gas-control system and a new type ribbon gas burner.

Heat Pumps

The first year of production on heat pumps was marked by good acceptance of the all-electric air conditioner. Completely packaged units in three- and five-horsepower sizes need only the addition of duct work for the two air circuits. The outdoor air circuit provides the winter heat source and the heat exhaust in the summer.

Air Conditioner

An improved design of a self-contained air conditioner, in three- and five-ton capacities, was pilot-produced in 1952. The design incorporates several internal changes that result in substantially

quieter operation and less vibration. A new hermetic condensing unit—containing compressor, motor, and condenser, within its welded steel shell—is responsible for a large portion of decreased noise and vibration.

Water Coolers

New explosion-proof water coolers for special industrial application—chemical plants, oil refineries, munition factories, and so on—were developed utilizing components similar to those used in standard water coolers. Adequate protective devices and covers are provided to remove spark-generation elements. These explosion-proof water coolers have a complete hermetic seal; they could even be safely utilized in spaces that are filled with explosive vapor mixtures.

Engineering Training and Education

To General Electric's long list of training and educational programs—Test Course, Advanced and Creative Engineering Programs, Manufacturing Training Program, Power Systems Engineering Course, Engineer Training Course, Sales Training Program, Business Training Program, and many others—two new undertakings were added in 1952: The Technician Program and the Simplified Drafting Project. Neither of these projects necessarily represents an advance in engineering progress; more nearly, they are progress in the engineering area.

Technician Program

Purpose of the Technician Program is to provide a background of experience that will qualify young men for various types of technical work within the Company. Thus, the end result will be to alleviate the engineer shortage because people will be available who are qualified to perform functions that do not challenge the full capabilities of graduate engineers.

The program was designed specifically for graduates of two-year college curriculums or their equivalent. Trainees are placed on three to six months rotating assignments in product test sections, engineering offices, and laboratories.

Aside from the on-the-job training that each man receives, there are available a series of technical courses in which qualified men can enroll. In addition, several colleges and universities in or near most G-E plant cities offer evening courses that yield credits toward an engineering degree. Many men on the program can thus work for their engineering degrees with the



SIMPLIFIED DRAFTING reduced 56 square feet of blueprint to four square feet. New method omits details that add nothing to the accuracy, completeness, or clarity of a drawing, saving draftsman's efforts and time

advantage of everyday experience to supplement their class work.

Men generally remain on the program for three or four assignments. The industrial experience they receive qualifies them to accept jobs in many diverse lines. Some go into laboratories or engineering-assistant positions. Others enter manufacturing, domestic or foreign service—or sales work. They can also remain in the testing field for additional experience. Opportunities are open to them in all branches of technical endeavor—mechanical work, electricity, thermal power, electronics, atomic power, and so on.

Simplified Drafting Project

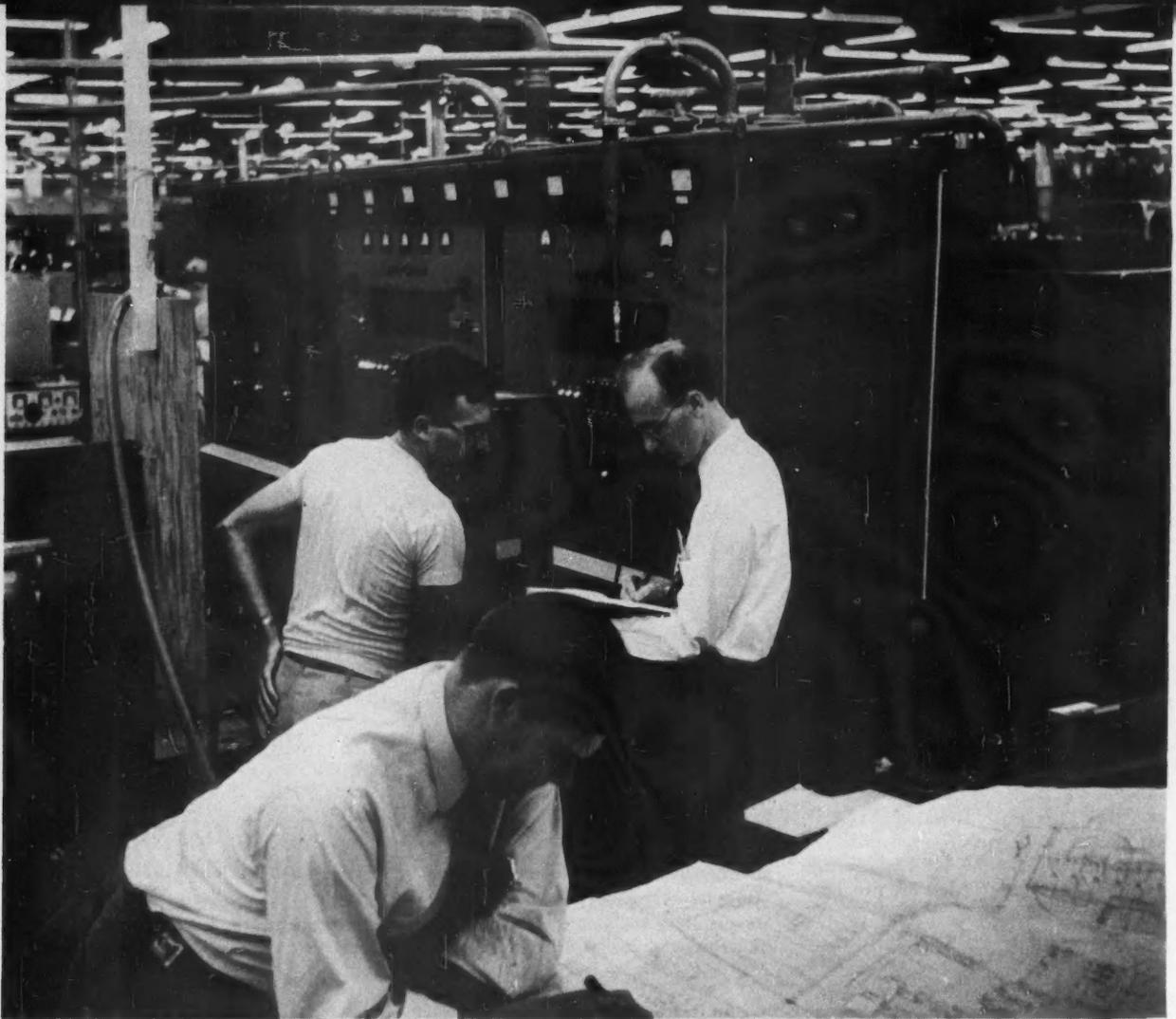
By the application of novel instructional methods, the more than 5000 General Electric draftsmen are being made conscious of how they can improve their contribution to the manpower shortage by making better and simpler drawings more quickly. The methods involved are many. At present three are

being highlighted: (1) simplification of delineation; (2) elimination of non-essentials; and (3) extensive use of free-hand drawing.

A number of drafting sections have adopted the slogan, "A Superfluous Line is a Waste of Time." Wherever possible, explanations are employed to complement illustrations and make it unnecessary to construct extra views on drawings. Draftsmen use delineation only when necessary for clarity and completeness.

"Progressive dimensioning," a simplified method, eliminates nonessentials by dimensioning progressively from datum lines. Not only does it require less space, but the drawing is clarified and the draftsman's efforts and time are saved.

Free-hand drawing, used judiciously, has proved both practical and economical. And all factors being equal, the actual drawing time for the average draftsman is reduced 20 to 30 percent.



LOW-CHANNEL TV AMPLIFIER WILL BOOST AN EXISTING 5-KW TRANSMITTER TO AN OUTPUT OF 100-KW EFFECTIVE RADIATED POWER

Electronics

In 1952 the industry-wide National Television System Committee (NTSC), under chairmanship of General Electric's Dr. W. R. G. Baker, was concerned with establishment of working standards for a compatible color-television system to be recommended to the FCC. A major part of the year was devoted to final analysis and exhaustive field-testing of the NTSC standards proposal, with resultant modification where necessary.

General Electric personnel were active on many panels and subcommittees of NTSC. On several occasions, engineers from other companies represented on the various panels assembled at Elec-

tronics Park, Syracuse, NY, with their latest prototype color-television receiver designs for field-test operations. The field tests were made possible through use of simultaneous color-television transmission equipment that was developed for laboratory system studies. A "live" color camera, installed in a studio for study of lighting effects on television reproduction, supplemented the transmission equipment.

Complementing NTSC work, development of color-television receivers was under way. Emphasis was on application of advanced concepts of communications. Many other phases of receiver-de-

velopment are currently being studied—tricolor picture tubes, UHF (ultra-high frequency) tuners, new types of phosphors, special receiving tubes, and antennas for the new UHF bands.

TV Transmission

When FCC lifted the three-year freeze on new television construction, great impetus was given to development and production of TV equipment. With the lifting of the ban came the Final Television Allocation Report, laying out an orderly plan for the growth of TV.

There are two main classes of transmitting equipment where the effects of

the new allocations are most evident. One is in high-power VHF (very high frequency); the other in UHF equipment. In high-power VHF the former maximum of 50-kw effective radiated power was raised to 100 kw for the low channels, and to 316 kw for the high channels. This creates a demand for high-power VHF amplifiers. The UHF range adds 70 channels to the original 12 of VHF. It is therefore expected that much of the future TV equipment will be made for these new channels.

VHF TV Transmitters

Development was successfully completed on a 35-kw low-channel amplifier. With a power gain of seven, this amplifier can be added to an existing 5-kw transmitter. With a relatively inexpensive three- or four-bay antenna, the 100-kw effective radiated power maximum is achieved.

For high-channel VHF a 20-kw amplifier employing air-cooled tetrodes was developed. When used with a 5-kw transmitter as a driver, and a 12-bay antenna, an effective radiated power of about 200-kw is obtained. For still higher power a 50-kw amplifier is being developed that uses new General Electric air-cooled tetrodes.

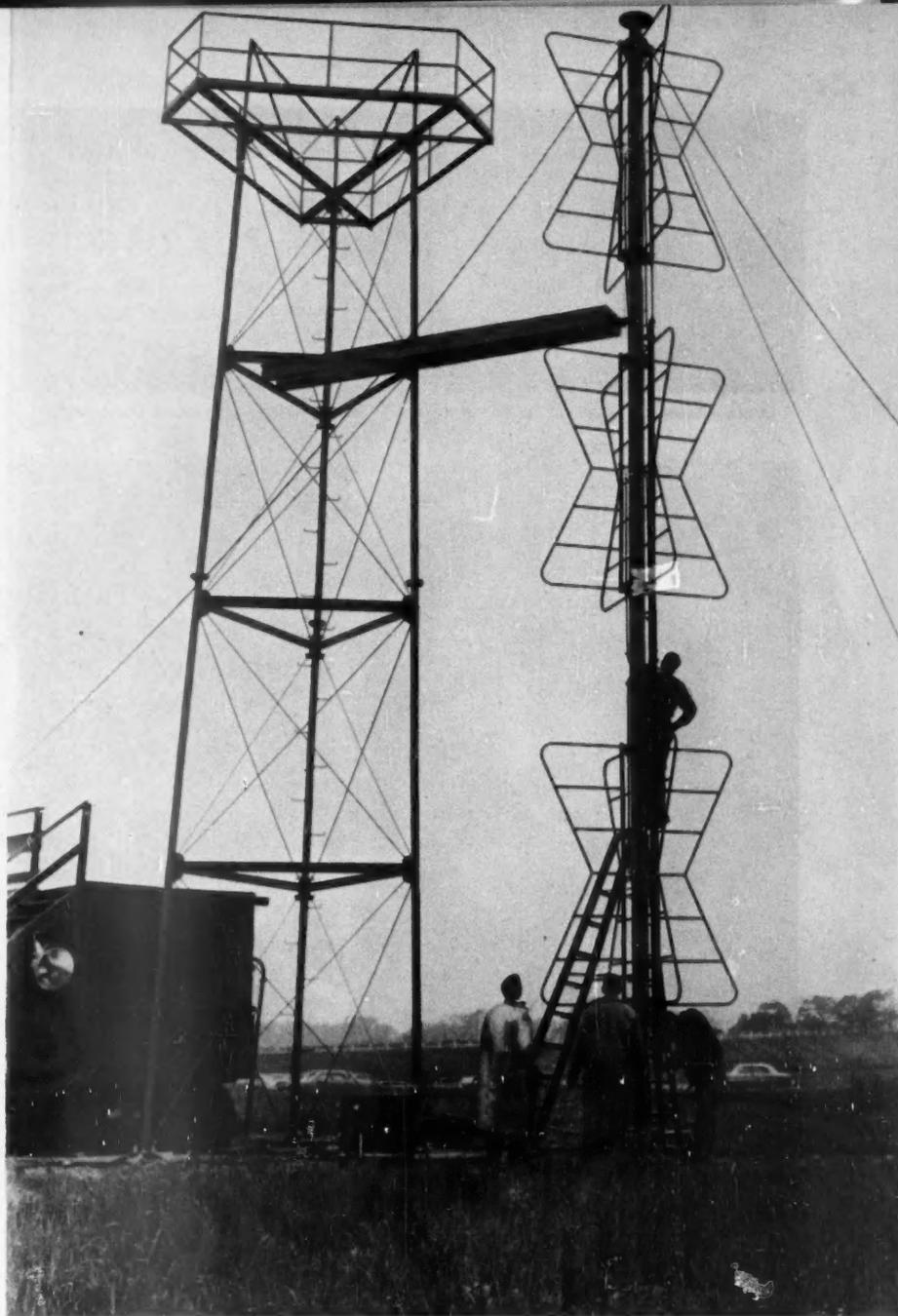
UHF TV Transmitters

A 12-kw UHF transmitter employs a specially developed klystron tube. Use of this tube appears to fulfill for the present the need for high power at ultra-high frequencies. Power gain is sufficiently high so that an exciter unit of only 100 watts is required. Successful operation of this transmitter was carried on for many months, at frequencies of about 500 and 750 megacycles.

Completely developed is a 100-watt air-cooled exciter unit designed to cover all 70 UHF channels and packaged suitably for transmitter use in smaller cities. Also, development is essentially complete on a one-kilowatt transmitter using the new General Electric air-cooled tetrode. This rating will be useful for communities whose requirements range between 100-watt to 12-kw ratings.

TV Antennas

To utilize the higher effective radiated power permitted by the FCC, the feed systems to General Electric VHF bat-wing antennas were modified. However, UHF antennas are capable of taking the maximum power now possible from UHF



THREE-BAY TV ANTENNA FOR STATION KPIX UNDERGOES A FIELD-TEST OPERATION

transmitters. Power ratings of needed accessory items—such as diplexers, adapters, filters, and so on—were also raised. One of several special antennas delivered in 1952 to meet particular requirements was side-mounted, permitting two stations to use the same site.

Studio Equipment

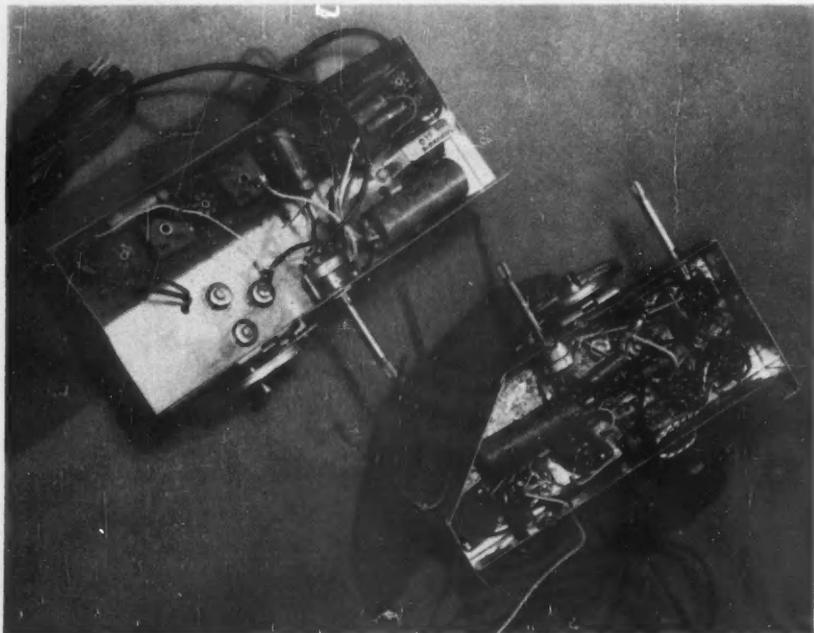
Developmental models of field-sequential color cameras and studio equipment

were completed early in 1952. These were used by 20th Century Fox in demonstrating the Swiss "Eidophor" system of color theater TV. Pictures produced on an 11½-by 15-foot screen were at least as bright as those in the best conventional 35-mm movie theaters and their quality is comparable to average color movies.

A new line of portable TV equipment using the image orthicon tube was an-



ULTRA-VISION G-E RECEIVER VS A COMPETITOR UNDER HIGH ROOM-LIGHT CONDITIONS



DIP-SOLDERED RADIO CHASSIS ON LEFT COMPARED WITH HAND-SOLDERED COUNTERPART

nounced during the year. The equipment is especially suited to the new TV stations for both remote and studio use. A new switching system permits the control panel to be easily remotated at a distance of 1000 feet or more, while leaving all the associated amplifiers and relays in the truck or other central control station. For example, the operator can now be seated with the announcer in the press box while a ball game is being televised.

Especially suited to automatic telephone-answering service, a versatile audio amplifier was designed for a large manufacturing company. The first group of amplifiers—completed early in the fall of 1952—are for an automatic information-service installation for a large Eastern concern.

Receivers

In 1952 many changes were inaugurated in television and broadcast receivers. Performance was improved, and unique mechanization methods have lowered assembly costs.

The "ultra-vision" feature of General Electric TV sets greatly extends contrast range and reduces room light reflections. It brings to the owner an improvement in picture quality that is not only measurable but immediately visible. Ultra-vision resulted from an all-out effort to combine techniques—electrical, mechanical, and optical—leading to improved picture quality.

A large number of tedious and expensive hand operations were supplanted by machine operations. Eighty percent of GE's production sets are now made on

a "dip-solder" basis. The many component leads and wires are inserted into eyelets of a special kind, and all soldering operations accomplished simultaneously by dipping the entire chassis assembly into a molten-solder tray. Not only is the total time thus reduced, but the crimping operation is also eliminated.

A miniature circuit was built in which leakage between conductors remains practically zero even after 30 days subjection to 96 percent relative humidity. This was made possible by an appropriate choice of board material and a coating system especially devised for the purpose. Additional features are weight reduction and improved accessibility for servicing.

Communications

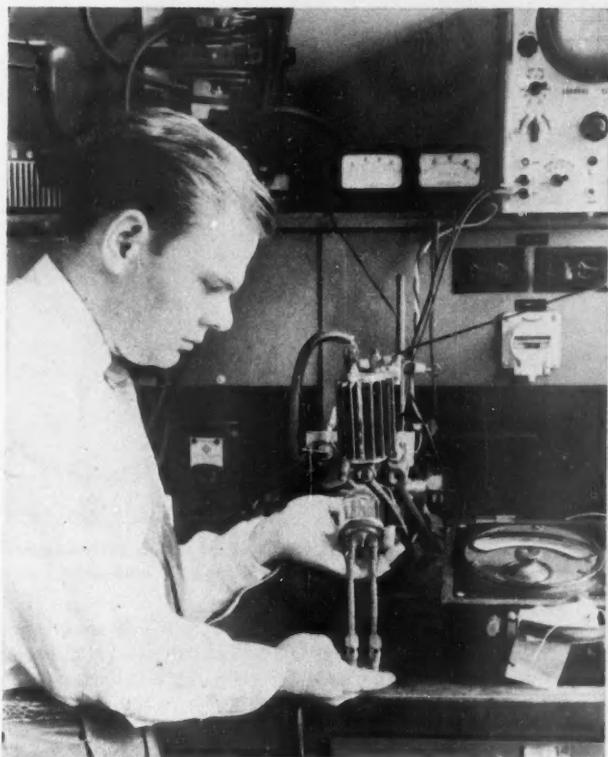
To further extend the use of radio channels, two-tone selective calling equipment was put in production. It permits selection of one of any number of the 900 mobile equipments in a system. One mobile unit—or any desired number of units—will receive the call while all other system units remain silent. Also, the equipment is applicable to a number of control functions when control of radio-transmitted signals from a remote point is desired.

FCC's allocation of channels for general industrial use released another large field for mobile radio users. Equipment was made available to meet limited power output specified for this service. In addition, a receiver is under production whose IF system can be simply adjusted in the field for operation on present wide channels or the narrow band.

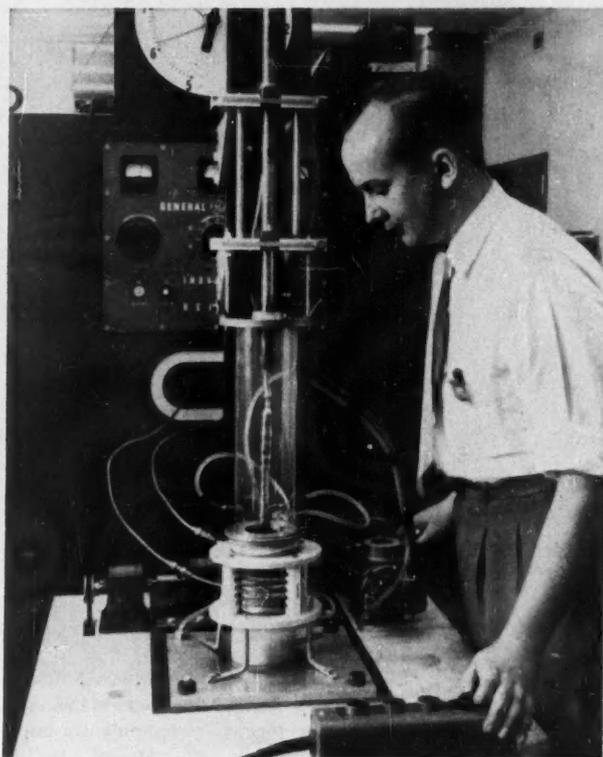
Mobile and station equipment for 450-megacycle operation went into pilot-plant production during the year. Of compact design, the unit's cost is low enough to make this band use economically practical.

In the marine field, FCC issued regulations covering use of VHF radio telephony in the 152- to 162-mc band for ship-to-ship and ship-to-shore use. To meet this need a line of equipment was produced that provides for transmission and reception on any one of up to six channels, and simultaneous monitoring of two channels.

New telephone equipment having a high order of receiver selectivity and excellent frequency stability was designed for power-line carrier-current communication systems. Operating in the 50- to 200-kc range, the equipment



GERMANIUM DIODE with water-cooling unit. Current through germanium wafer exceeds that recommended for a copper con-



ductor of the same cross section. Germanium crystals (above) are drawn from germanium melt by a new crystal-pulling device

provides voice communication over high-tension lines of electric utilities. Among many other improvements, a new all-electronic method of voice switching is used. The method permits duplex communication on a single frequency with maximum switching speed and minimum noise from switching transients.

A new line of 2000-mc microwave equipment is undergoing manufacture. In addition to having 24 voice-communication channels, standby equipment and diversity reception are available to give uninterrupted service. The new transmitter operates at 10-watt peak output, and utilizes lighthouse tubes.

Microwaves also entered the high-speed protective-relaying field in 1952. Using 960-mc microwave transmission of high-speed tones, it was possible to achieve high-speed protection without the need for continuous wire circuits between the two points. The first installation of this service was made for two large Eastern utility companies.

Germanium Diodes

Theoretical study of conduction in small diffused-contact germanium diodes

was carried forward in 1952, and methods for improvement of diode back-resistance characteristics resulted. After successful laboratory tests, high-current diffused-contact diodes were released to engineering design. These diodes are capable of several hundred amperes peak current at 150-volts peak for a one square-centimeter germanium wafer with water cooling.

About 7000 germanium diodes and 1400 vacuum tubes are used in a digital computer for the Air Force that reached its final stages of completion during the year. This computer has the largest "memory" yet incorporated in any computing device. Its primary function will be solving complex mathematical problems—at an operational rate of 110 calculations per second—in such fields as aircraft design, guided missiles, and ballistics.

Transistors

Transistors can now be operated at considerably higher power levels than heretofore possible. This was accomplished through a study of the high-temperature characteristics of germani-

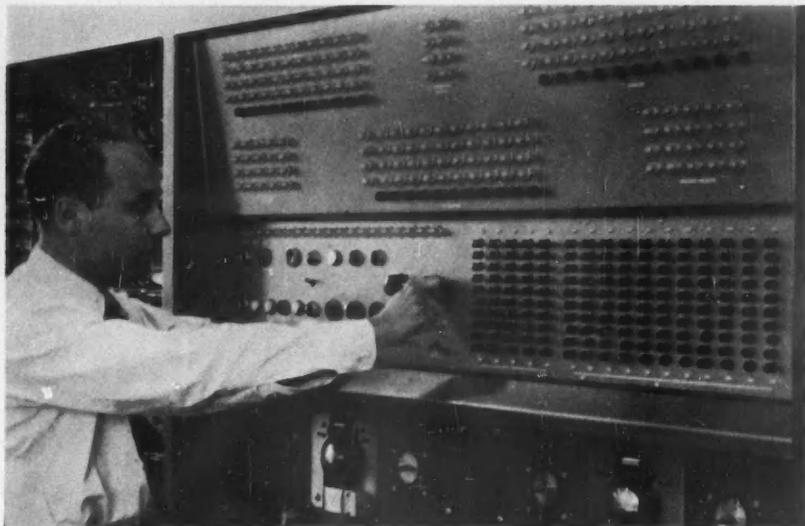
um, and by the special mounting of transistors for improved heat-transfer. As a result, the audio portion of a developmental portable radio-receiver was replaced with transistors. Improved performance at considerably less power consumption was obtained.

Other studies were made pertaining to circuit applications of a variety of transistors. Applications were achieved in integrating and differentiating circuits, relaxation oscillators, multivibrators, and other similar circuits.

Cathode-ray Tubes

Cathode-ray tubes for television picture service increased in size. An 18½-by 24-inch rectangular tube was developed to meet the trend. It has a gray faceplate that increases picture contrast and detail under high room-light conditions, and a reflective metal-backed screen that increases light output about 100 percent over similar size tubes of the same voltage.

Development work on the design of tricolor television picture tubes was particularly fruitful. Previously, it was necessary to manufacture these tubes



SEVEN THOUSAND germanium diodes are used in this digital computer. It has the largest "memory" yet incorporated in any computing device. Control center is shown

from noninterchangeable mated parts using tools made for one particular assembly only. By careful analysis of requirements and procedures, a design was developed that eliminates special handling. Thus mass production becomes feasible and brings the realization of an all-electronic color-television receiver one step closer.

Another cathode-ray tube development of 1952 is a five-inch view-finder tube. It is used in television cameras being produced for theater projection of color television. The metal-backed screen of the new tube provides the required brightness and picture definition.

A number of radar and oscilloscope tubes were introduced for use in both military and industrial equipment. One feature is the metal-backed screen originally developed for picture tubes. The screen reduces undesirable screen-charging and ion-spot blemishes, thus permitting accurate plotting directly on the tube face. A new 17-inch tube is unlike any other; it has a tilted neck that positions the deflected spot $1\frac{1}{8}$ inches along the major axis from the geometric center of the rectangular tube face. This construction makes the tube especially useful in radar navigation service.

Transmitting Tubes

The first air-cooled transmitting tube for the UHF television field was introduced during the year. Of ceramic and metal construction, the new tube is

designed to operate with a peak output of 1 kw at frequencies up to 900 mc. It provides a tube for service where use of water and installation of water connections are impractical.

Also of interest in the UHF television field is a klystron tube for transmitters. Developed by Varian Associates according to General Electric specifications, the tube provides a synchronizing peak output of 12 kw at up to 890 mc—the most powerful tube yet developed for UHF telecasting.

Another development—a ceramic-and-metal forced-air-cooled tube for VHF communications service—is capable of output up to one kilowatt.

Receiving Tubes

In the receiving-tube field, development of a mixer tube and an r-f amplifier tube completed requirements for a tuning system that will operate over both the old television channels and the new UHF channels. A third tube, a local oscillator, had previously been available. The three tubes make possible a single combined tuner circuit operating over the entire VHF-UHF television channels. Simple in layout, the tuner circuit reduces the components required, has low noise level, reduces radiation interference, and improves selectivity.

A power-output pentode for television receivers was developed for applications where only small driving voltages are available. It was specifically designed for use with a combination limiter and dis-



RECEIVER TUBE of tuning system operates on old and new TV channels

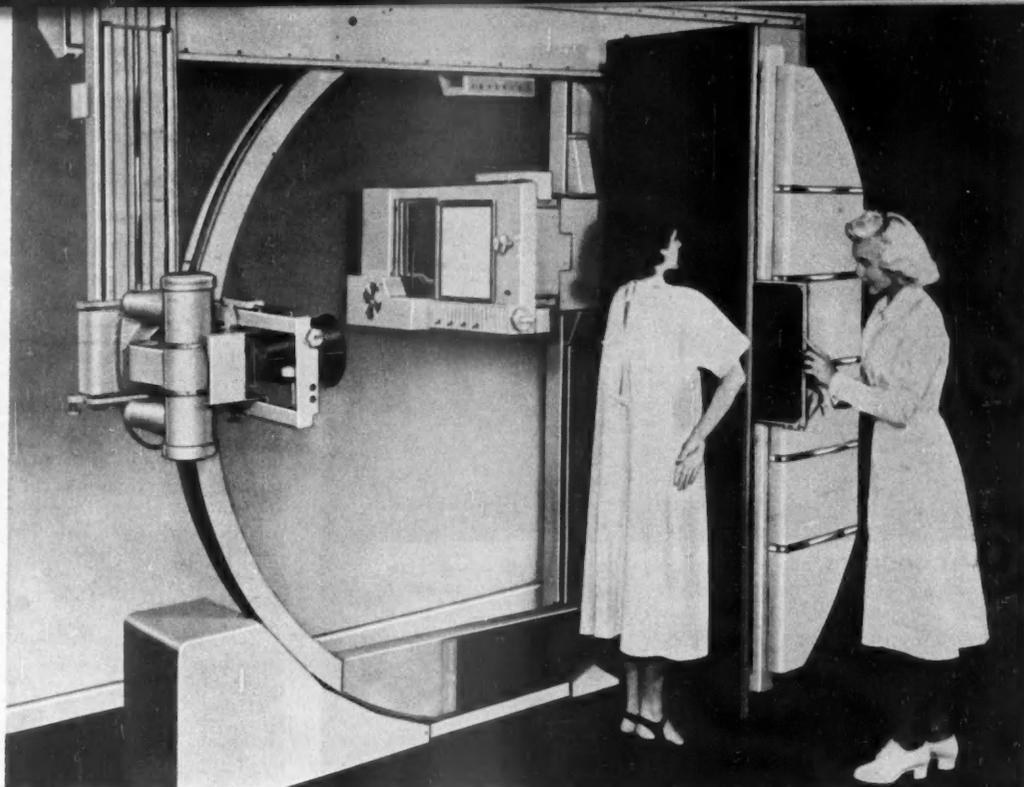
criminator tube, announced about two years ago. The combination eliminates the need for two additional tubes previously required.

A group of especially manufactured and exactly tested versions of standard-type receiving tubes were developed for applications requiring maximum operational reliability. Use of the tubes has resulted in a substantial reduction in tube failures. In commercial airlines equipment, failures were reduced to about one-twelfth those of standard tubes.

Industrial Tubes

There has been a growing demand for tubes—better adapted than home-receiver types—to meet stringent operating conditions in industry. As a result, two tubes particularly designed to meet the requirements of this field were introduced. One is a miniature twin-triode, with controlled balance of the cutoff characteristic between two sections, for use in high-speed digital computers. The other is a half-wave rectifier tube, presently being used in dust-precipitator applications. About the size of a conventional receiving tube, it is rated 18,000 volts peak inverse and 30 ma peak.

Other developments during the year include introduction of a number of sub-miniature tubes and a line of hydrogen thyratron tubes. The subminiature tubes were developed for military aircraft applications.



RING-CENTERED DIAGNOSTIC X-RAY UNIT IS A RADICAL DEPARTURE FROM CONVENTIONAL DESIGNS

Electromedical

Savings of thousands of dollars in hospital construction costs are promised by a radically new "ring-centered" type diagnostic x-ray unit, called the Imperial, introduced during the year. Its table rotates through 180 degrees on a ring approximately eight feet in diameter, and all activity is concentrated within the single central-ring area. An average of 540 to 864 cubic feet of room space is thus saved.

Because the table is ring-mounted, the many pounds of counterweighting needed to balance the fluoroscopic screen and its supporting structure were cut 30 percent. Most of the counterweighting is now mounted in the ring itself. Equally important is the replacement of the bulky tube stand with an easy-sliding tube hanger that moves on an overhead rail.

The new unit makes obsolete conventional designs that are based on the double-pivot principle of angulation. It also makes possible new advantages—such as movement of the table toward and away from the physician, either right- or left-handed operation, and unin-

terrupted angulation through horizontal if desired—that formerly were impossible.

Inductotherm

A new diathermy Inductotherm unit, with an electrosurgical unit as an integral part, has an output from 50 to 75 percent higher than its predecessor. Without actual contact, the unit generates a controlled heat deep within the body tissues. Blood vessels are thus dilated and an increased blood supply created.

Cable, contour, and air-spaced electrodes can be used with the unit whose increased output is achieved without overloading its tubes. But as in the previous model, frequency of output is 13.56 megacycles—a frequency that tends to limit heating effect to deep tissues without excessively heating surface tissues.

Cardioscribe

A completely restyled direct-reading electrocardiograph was introduced. The instrument is so designed that the lead

shifting delay-time is drastically cut, thereby reducing time needed for heart examinations. Operation in tropical climates is improved by miniature electric heaters inside the case.

Ordograph

The ordograph, a device for body-section radiography, provides a high x-ray film quality not previously obtainable. It can be used with the patient in either the horizontal or vertical position, and is adaptable for use with several types and models of G-E x-ray equipment.

In body-section radiography, unlike regular radiography, motion is required to blur all body tissues except the precise layer which is under examination. The ordograph causes the x-ray film and the x-ray tube to move in opposite directions during exposure, thus revealing only those areas of the body lying within the plane along which the axis of motion pivots. This technique permits observation of areas otherwise hidden by intervening body structures, or better visualization of areas that are only partially obscured.



FLUORESCENT FLOODLIGHTS allow faster passenger loading and maintenance work. Each aluminum fixture contains two eight-foot-long fluorescent lamps



SIX-FOOT STREET LIGHT is a new fluorescent unit that doesn't blink or flicker and lights promptly after being turned on. No external starter is used

Lighting

In the 73rd year of electric lighting the fluorescent lamp caught up with and passed the incandescent lamp bulb as the chief electric source of general lighting in America.

A system of high-frequency operation of fluorescent lamps now in development indicates a coming advance in light output and conservation of materials. Such a fluorescent-lighting installation is already supplying a plant-growth laboratory with virtually daylight levels.

Airport Lighting

Giant fluorescent floodlights that produce practically glareless light are in use for the first time at an Eastern airport. The installation totals eight G-E aluminum fixtures, bracketed to the handrailing of the observation deck, 15 feet above ground. Each fixture contains two eight-foot-long fluorescent lamps. A highly polished reflector directs light from lamps through clear plastic windows to the loading area. The new fluorescent installation provides a substantial increase in illumination with smaller power consumption than its predecessor.

Rapid Start Fluorescent Lamps

Development of a new type of fluorescent lamp improves in many ways upon the performance of those now in general use. The new lamps start quickly and smoothly without the aid of external starters. Named rapid start, they are used with especially designed ballasts and are being made in the popular 40-watt size for general lighting in commercial, industrial, and residential installations.

In a rapid-start lighting system all lamps controlled by one switch will light promptly—within about one second after being turned on. And they will not blink or flicker throughout their lives.

Street Lighting

A six-foot fluorescent street light is the latest development in modern street lighting. It provides a constant source of practically glareless light despite outdoor temperature changes that normally decrease the efficiency of

fluorescent lights. Through a large, clear-plastic housing, light is reflected from the four 100-watt rapid-start fluorescent lamps. The entire fixture weighs about 100 pounds and, unlike other fluorescent street lights, houses its ballast within the unit.

Dimming Fluorescent Lamps

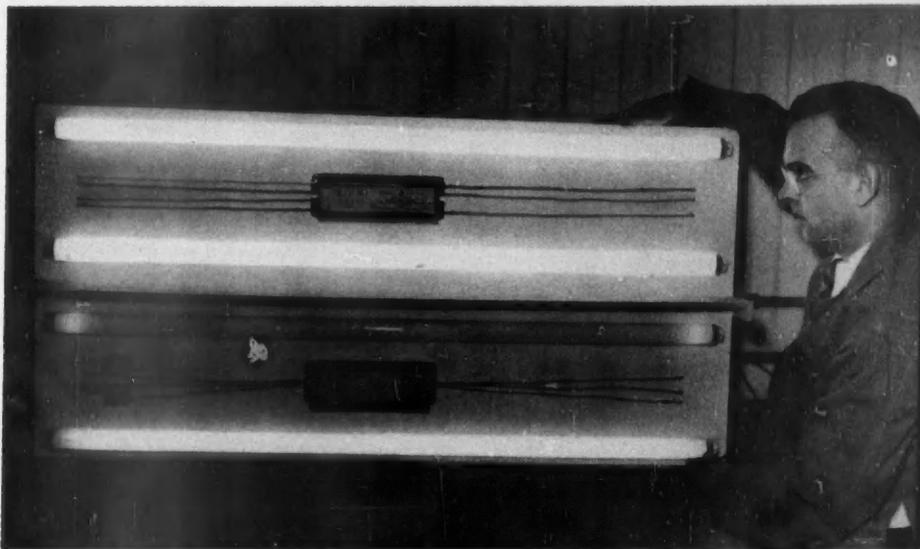
A practical system for dimming or brightening fluorescent lamps smoothly and efficiently—something the lighting industry has striven for since the inception of fluorescent lighting—was announced in 1952. Brightness of fluorescent lamps can now be controlled merely with the turn of a knob. And by means of a circuit that maintains the starting voltage but changes the current to affect light output, the lamps can be turned on instantly at any point in the dimming range. This system greatly increases the flexibility of fluorescent lamps and their range of uses. The new control is available in two sizes: one to dim up to eight standard 40-watt fluorescent lamps; the other up to 35-watt lamps.

Miniature Lamp

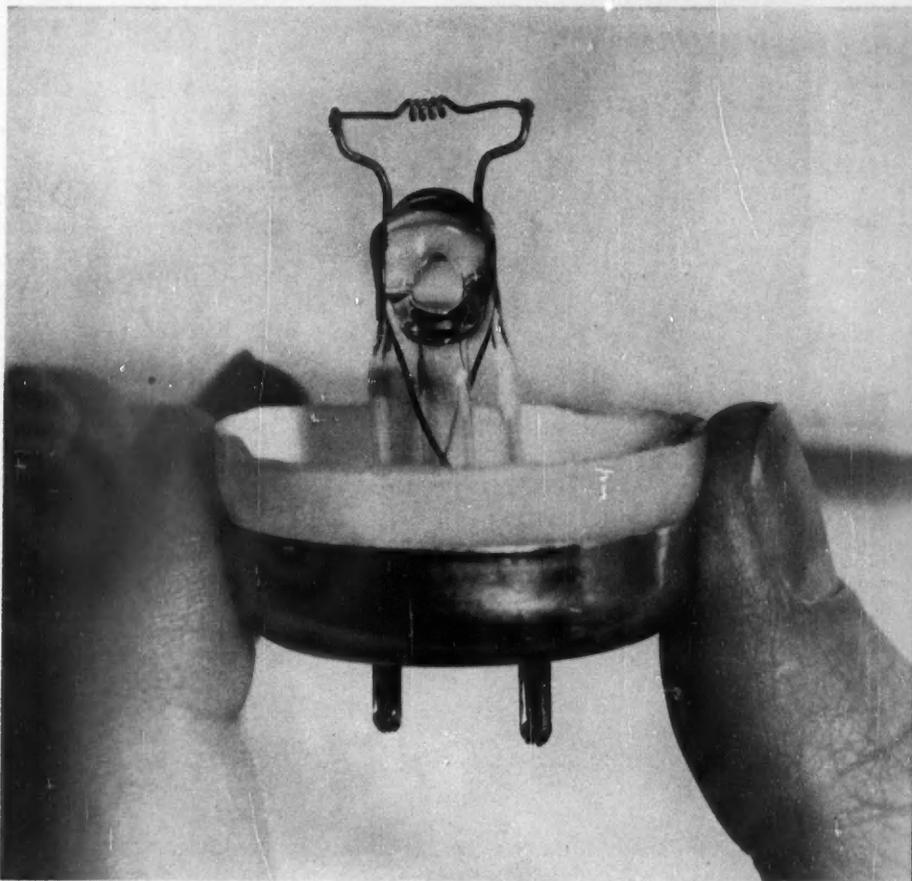
After more than two years of research a method was devised to utilize automatic machinery in the manufacture of a tiny lamp that the Air Force requires by the millions. The miniature lamp is used to illuminate the hundreds of instruments and controls in a modern airplane. Rated at 28 volts, the lamp is so tiny that its glass globe is little larger than the head of a kitchen match. As a result of the changeover to automatic production methods, General Electric was able to effect a \$10-to-\$25 per plane saving to the Air Force.

Aviation Beacon

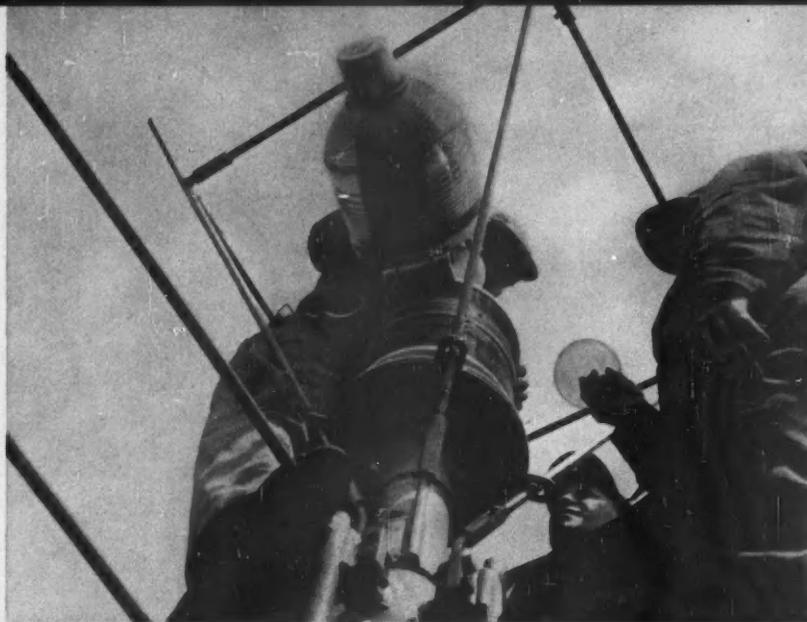
Special shock-resistant G-E lamp bulbs were installed in a red-warning beacon unit atop the television-antenna tower on the Empire State Building in New York City. The new hard-glass lamps were developed to replace ordinary ones that proved unable to withstand severe atmospheric punishment. Made of heat-resistant glass, the lamps will not break when water strikes the hot bulb. Their more dependable performance reduces the frequency at which bulbs must be replaced—at three-month intervals—at a cost of about \$150 per replacement. Their success in the Empire State installation indicates they will be widely



STARTING SPEED of rapid-start fluorescent lamp (top) compared with the conventional prestart type. The improved lamps utilize newly designed ballasts



CATHODE of rapid-start fluorescent lamp requires less energy to preheat. More life for its size is given than for any cathode that was previously used



HARD GLASS LAMPS installed in red beacon unit atop Empire State Building's TV antenna (top) are heat and shock resistant. Aviation beacon (circled) must withstand bad weather. Ordinary lamps were replaced after hard storms

used as a source of illumination for warning lights on towers, bridges, buildings, and other structures that constitute an aircraft hazard.

Indirect-lighting Effect

Developed for use in one- or two-socket ceiling fixtures, a new 100-watt lamp combines utility and attractiveness. The new style of bulb has a bowl whose shape directs two-thirds of the light upward to the ceiling, creating an indirect-lighting effect. Its lower portion is covered with a soft-toned permanent-enamel finish that filters and mellows one-third of the light directed downward.

Industrial Lighting

Two new mercury lamps for general lighting were introduced during the year. They are the first of their type to have reflectors built into the bulb. Both are designed for industrial use, especially in areas—such as foundries and welding shops—where dirt collection and grime cause severe reduction in light levels.

Produced in the 400-watt size, the lamps have a life rating of 3000 hours at five hours per burning start, and 4000 hours at 10 hours per start. One lamp generates light of the regular mercury color, while the other lamp—physically the same but with a phosphor coating on the inside—generates light of an improved color quality.

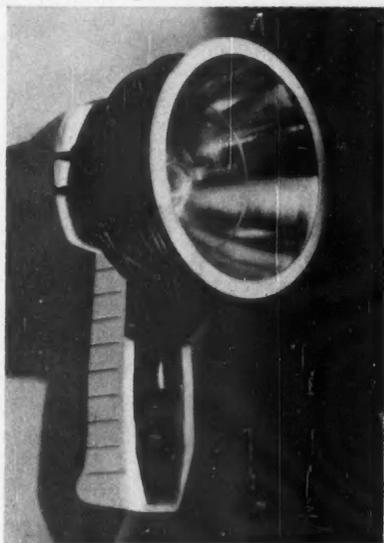
Another development in lighting industrial plants was a new larger mercury lamp. It is a highly efficient 1000-watt mercury lamp for general industrial use where medium- or high-bay lighting is desired.

Most efficient of GE's general-lighting mercury lamps, it is designed to fill in the gap between 400- and 3000-watt lamps in the mercury-lamp line.

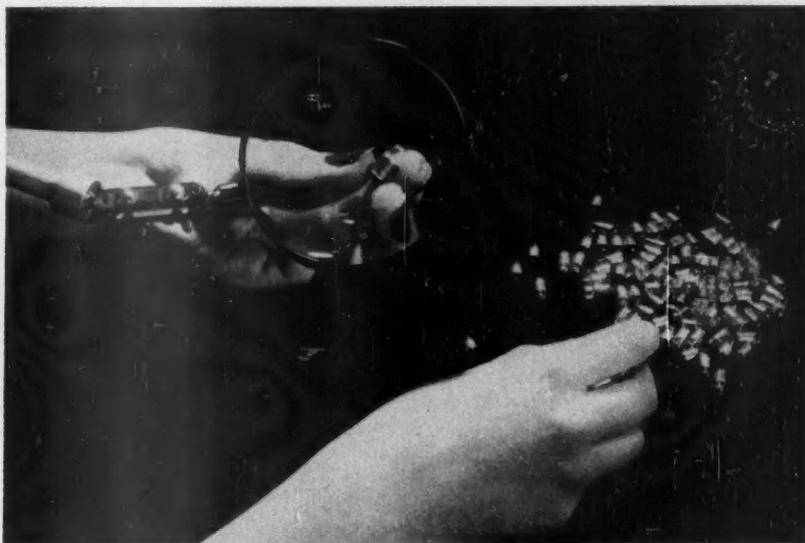
Two new 500-watt reflector lamps were developed for industrial outdoor illumination, service-station lighting, and similar applications. One produces a flood beam; the other a spot beam. Both are made of heat-resistant glass, and preliminary performance data indicate a mean candlepower in the central 10-degree cone of approximately 20,000 for the spot and 4000 for the flood lamp.

Aluminum Bases

In 1952, aluminum was used instead of scarce brass for a large portion of



SPOTLIGHT for automobile plugs into the cigarette lighter receptacle



TINY LAMP for Air Force is now manufactured with automatic machinery. A saving of from \$10-to-\$25 per plane was effected by the new method

General Electric's output of bases for incandescent light bulbs. Lamp bulbs with aluminum bases have appeared on retail counters in all parts of the country. The new bases have the advantages of being resistant to tarnishing and maintaining a better appearance in general.

The successful use of aluminum required an alloy that would withstand the high temperatures used by the machine in which lamps are assembled. It also required development of a solder and flux suitable for high-speed automatic soldering operations. Aluminum will be used almost exclusively in the future for bases of most incandescent and fluorescent lamps.

Photolamp

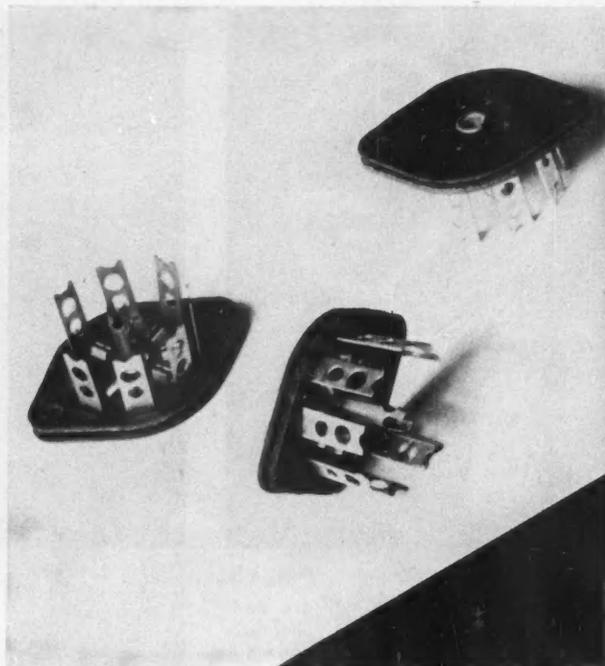
Added to General Electric's line of photolamps during 1952 was a new photoflash blue lamp. Designed for use with daylight-type color-positive and color-negative film, the lamp assures good color rendition. It delivers approximately 820,000 peak lumens of light having a color temperature of 6000 K, which accurately parallels that of daylight-type color films.

Auto Spotlight

Designed for motorists by the Monowatt Department of General Electric, a new low-priced auto spotlight provides a powerful concentrated beam of light.



CIRCLINE FLUORESCENT LAMPS are now made in 8-, 12-, and 16-inch diameter sizes. For some purposes they are more effective than straight tubes



HIGH-PRESSURE LAMINATED PLASTICS MATERIALS ARE EQUALLY AT HOME IN KITCHEN OR AS HIGH-FREQUENCY CIRCUIT INSULATION

Chemical and Metallurgical

A new type of high pressure laminated plastic was developed specifically for insulation on Navy apparatus. Composed of glass fiber mat bonded with melamine resin, it will act as a replacement for another type of material at a 16.5 percent cost saving.

Demands in the electronic industry for insulation in high-frequency circuits led to development of another laminated plastic material having a low dielectric-loss factor. It is particularly remarkable for its high insulation-resistance under high humidity conditions. After 96 hours of exposure to 90 percent relative humidity at 35 C, the insulation resistance is above 80,000 megohms.

Success in bonding laminated plastic to steel was finally achieved with two industrial adhesives put on the market by a large manufacturer. When applied according to instructions, they have withstood the most severe adhesive tests that could be devised.

Fire-retardant Resin

A new chlorinated ethoxyline product has proved suitable for laminating glass-

cloth. Highly fire-retardant, the resin is rigid and has impact resistance similar to standard types. It has the unusual electrical property of dropping slightly in power factor with a temperature rise from 25 C to 150 C.

Mica Mat

A long sought objective is now a reality—mica is being formed in continuous lengths on a production basis. It now appears that America need no longer be dependent on foreign sources for the majority of its mica for rotating equipment, appliances, and other uses.

The product, called mica mat, readily lends itself to impregnation by various resins to form tapes and wrappers, composites, segment sheets, and other standard mica products. Since the replacement of the relatively expensive mica used in tapes offered the greatest opportunities, this field was invaded first. Several varieties of tapes were developed using silicone, alkyd resin, asphalt, and other binders. Large quantities of mica mat are now running in numerous pilot motors and generators.

Surface-coating Films

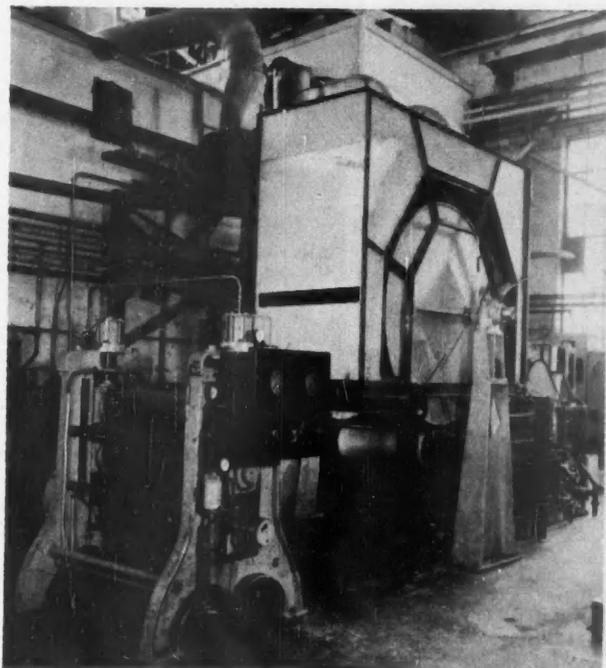
Two new test methods for studying surface-coating films will aid in development of improved materials. One method yields a quantitative measure of the flexibility of films, while the other is important in studying factors underlying the appearance of similar films.

Textile Printing Resin

Recognizing the possibilities of reducing costs in textile printing plants, a vehicle for textile printing was developed. It is sold directly to the printer with recommendations for using it in preparing printing compositions in his plant. This new development has permitted a 10 to 30 percent reduction in operating costs to the textile printer.

R-108

Synthetazine 100, an R-108 Epoxy resin combination, is finding acceptance as an all-purpose interior drum lining for the shipment of many corrosive chemical products. A coating containing R-108 is also being used commercially as an interior and exterior lining for



PAPER MACHINE (ABOVE) MAKES MICA MAT IN CONTINUOUS LENGTHS FOR INSULATION IN VARIOUS TYPES OF ELECTRICAL APPARATUS

domestic hot-water tanks. Field trials of 18 months' duration show the coating to be untouched; the goal is eventual replacement of all galvanized hot-water tanks.

Coil-impregnating Varnish

A trend in requirements for coil impregnants has been toward greater heat-resistance. But a wide gap in the performance of available products exists; namely, from the better Class A products on through to the silicones useful in the Class H range.

In the past year a product was developed that seems to have the properties to fill this gap satisfactorily. In addition, excellent bonding to mylar and silicone resin surfaces was obtained. These properties promise longer life for coil-structure insulation where Class B temperatures are encountered and eliminate use of expensive Class H materials.

Rubber-phenolic Varnish

It is now possible to make a thermoset laminate that is flexible and tough as well as strong, through the use of G-E 12359 rubber-phenolic varnish. The varnish is made from a modified phenol-formaldehyde resin and a special grade of acrylonitrile type of synthetic rubber.

It can be used with various papers and fabrics generally employed in the laminating industry. Laminates made with 12359 are tough, flexible, and possess good electrical properties, but their most outstanding property is their ability to withstand repeated mechanical shocks.

Silicones

A new silicone-rubber compound for insulating cable and wire can be extruded and cured on standard cable-processing equipment at the high speeds normally used in cable making. Characterized by ease of processing, storage ability, and excellent electrical and physical properties, the compound is particularly resistant to water and humidity. Cables composed of this compound have good insulating properties after a 20-minute exposure to an open flame.

Temperature limits of silicone rubber were extended by the development of two new compounds. One, an extreme low-temperature silicone rubber that remains flexible at -110 F, is finding many uses in aircraft and military equipment. The other, a high-temperature silicone rubber that withstands 600 F for required periods of time, is being used to make flexible heater-ducts for jet engines.

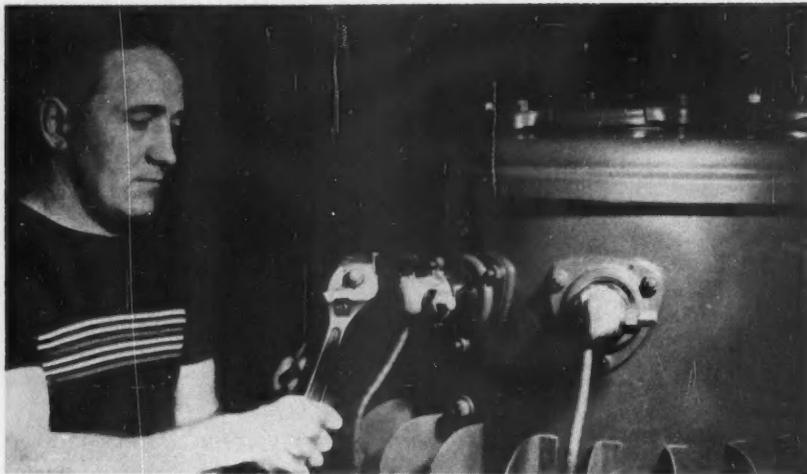
A silicone mold-release emulsion was developed to aid in casting metal parts by the shell-mold process. Diluted with water and applied as a spray, the silicone resists temperatures of the molten metal and gives easy release of the casting from the mold.

Sodium methyl silicate, a new material, dissolves in water to form a solution that when applied to brick, mortar, concrete, or other materials renders them impervious to liquid water. In addition, it acts as a curing aid for high-strength concrete. The solution can be used to give a water-repellent quality to paper, textiles, water-base paints, and many other materials. Another silicone development, making textiles permanently water repellent, is a silicone-organo-resin combination.

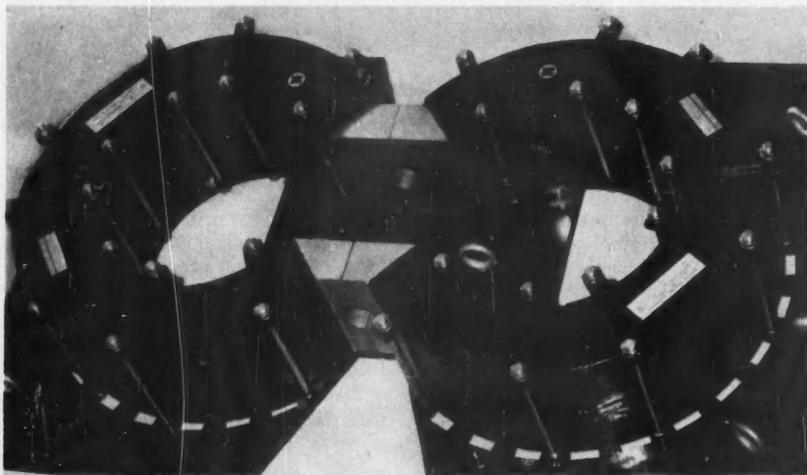
The use of silicones as dielectric liquids became a reality in 1952. Several companies began producing silicone-fluid-filled capacitors and impulse transformers.

New Nonmagnetic Material

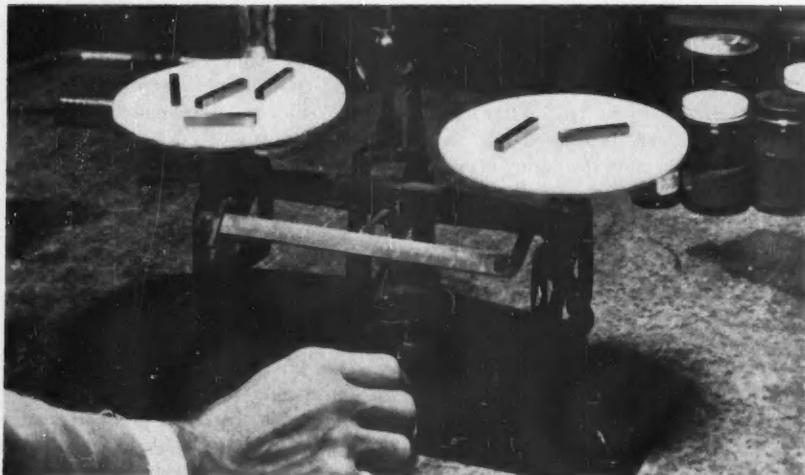
A new nonmagnetic age-hardened austenitic material, having low strategic-alloy content and a 15 percent greater strength than any presently available material, was developed. The new alloy is useful primarily for such high-stress



TERMINALS OF NEW ALLOY RESIST FAILURE IN CORROSIVE ATMOSPHERE



ALNICO-5 MAGNET, ONE OF LARGEST EVER PRODUCED, IS FOR MILITARY USE



CHROME CARBIDE'S LIGHTNESS SHOWN HERE; FOUR BARS BALANCE TWO TUNGSTEN CARBIDE BARS

applications as turbine-generator retaining rings.

Core Loss

For the first time design engineers can predict high-frequency core losses from measured, static, magnetic properties. Theoretical and empirical relations were derived that connect a-c core losses in modern magnetic materials to the static hysteresis loops and other determining factors. These modern alloys include high-permeability thin-gage materials used in high-frequency applications, and 0.014-inch oriented silicon steel used in power apparatus.

Copper-base Alloy

Nonferrous metal parts—such as pressure terminals, bushing clamps, and line hardware—will sometimes crack and break when simultaneously subjected to tensile stress and a corrosive atmosphere. Stress-corrosion failure is the cause. A new copper-base nickel-silicon alloy resists such failure in very corrosive media while stressed to a load just short of its ultimate strength.

Trepanning Technique

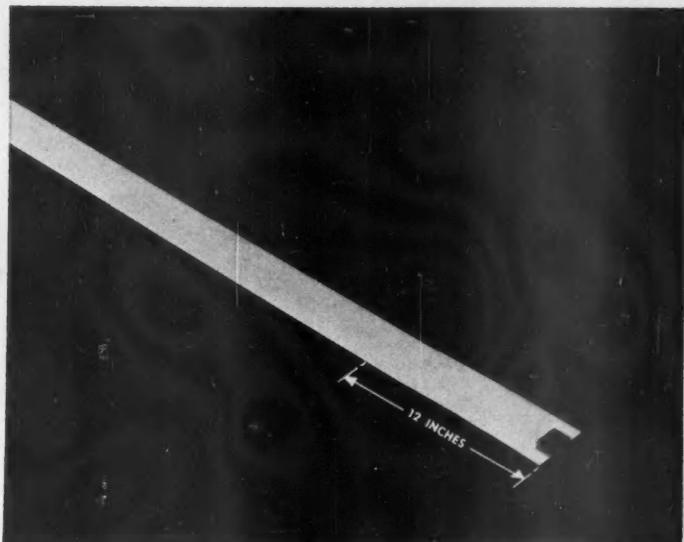
Results of an advancement in trepanning technique utilizing Carboloy carbide tips will be important to the manufacture of gun barrels and other industries where deep, hollow shafts must be bored. It allows deep holes to be produced 16 times faster than former methods employing a spade drill.

Alnico-5

One of the largest alnico-5 magnets ever produced was designed and manufactured in 1952 by the Carboloy Department of General Electric. Weighing 624 pounds, the huge magnet is being used in a classified military application. Despite its size, no major manufacturing problems were involved. However, the usual method of inducing magnetization could not be used; instead, a special electrical coil was wrapped around the magnet to induce the field. An electrical input of 30,000 amp was used during the magnetizing process. After magnetization it had a strength 1.6 million times that of the smallest permanent magnet made by Carboloy Department.

Chrome Carbide

Chrome carbide 608, announced in 1951, is being tested in the petroleum, food-processing, and chemical industries.



ELECTRIC RADIANT HEATING PANELS (ABOVE) ARE FINDING NEW USES, WHILE A PRESSURE-LOCK TERMINAL SPEEDS CONNECTIONS

... For Building Construction

Special types of electric heating panels were developed during the year for a large variety of interesting applications. These panels are in addition to standard panels used in home heating systems and other buildings as the only heat source, or as a supplement to other systems.

The method of making these special panels is similar to that of standard panels. A copper-alloy wire grid is preformed on a winding board. This grid is sandwiched between two layers of phenolic impregnated paper and held in place by an adhesive. Additional sheets of phenolic paper are placed on either side of the "sandwich" and a thin sheet of aluminum foil is added to each side of the layup. The layers are stapled together, then pressed. Standard layups provide a semirigid panel approximately 0.040 inches thick after pressing, and sizes vary from 2½ to 36 inches in width, and approximately 70 inches in length. When only natural ventilation is supplied, heat dissipation is 20 watts per square foot. Wattages may be varied by changing the winding. Maximum temperature at the surface of the panel is about 150 F.

New applications for these panels include defogging of bathroom mirrors and warming commercial refrigerators. Bathroom mirrors are kept clear by means of a panel that fits the back of the

medicine-cabinet mirror. Enough heat is supplied to keep the mirror temperature about 15 degrees above room temperature. Sections between doors in walk-in type refrigerators must be kept above 32 F to prevent the doors from freezing closed. A panel that dissipates 65 watts corrects this situation.

Other applications include foot warmers for airplane pilots, camera magazine heaters, closet warmers, and navigation table heaters.

BX Cable

Smaller diameter, lighter weight, and greater resistance to impact and crushing have been made possible through the redesign of BX armored cable. The new design features a rot- and flame-resistant glass braid over the individual insulated conductors in place of the old conventional cotton braid. By taking advantage of the glass braid characteristics, it was possible to reduce the overall diameter and produce a cable much easier to handle and install.

Safety Switches

The Trumbull Electric Department of General Electric extended their line of HCI safety switches to include the 200-amp rating. In addition, the introduction of a new gasketed enclosure makes all ratings in the line dust resistant.

Panelboards

Panels using plug-in-type circuit breakers have been made more adaptable and more convenient for the electrical distributor and contractor by providing for knocked-down shipment of component parts to the distributor. This enables the distributor to service a wide variety of customer requirements from a minimum of separate boxes.

Fuse Puller Switches

A line of fuse puller switches for service entrance and branch circuit protection was introduced that incorporates as basic building blocks pullout units in capacities of 30, 60, and 100 amp, two-pole for single-phase, three-wire, 125- to 250-volt a-c service.

Wiring Devices

Ease and speed of wiring are among the advantages of a new line of single-pole and three-way switches, outlets, and keyless ceiling lampholders developed by the Monowatt Department of General Electric. A pressure lock terminal makes it possible to obtain firm, positive electrical and mechanical connections simply by stripping the conductor leads (No. 10, 12, or 14) and pushing them into terminal holes. Leads are totally enclosed and can be released with a small screwdriver.



EIGHT-HOUR PRODUCTION OF WIRE REFRIGERATOR CONDENSERS BY THIS AUTOMATIC MACHINE REQUIRES NEARLY 150 MILES OF WIRE

Appliances

Three completely restyled refrigerator-freezer combination units and two fully automatic refrigerators highlight the new General Electric refrigerator line. These are in addition to four manual-defrost refrigerators.

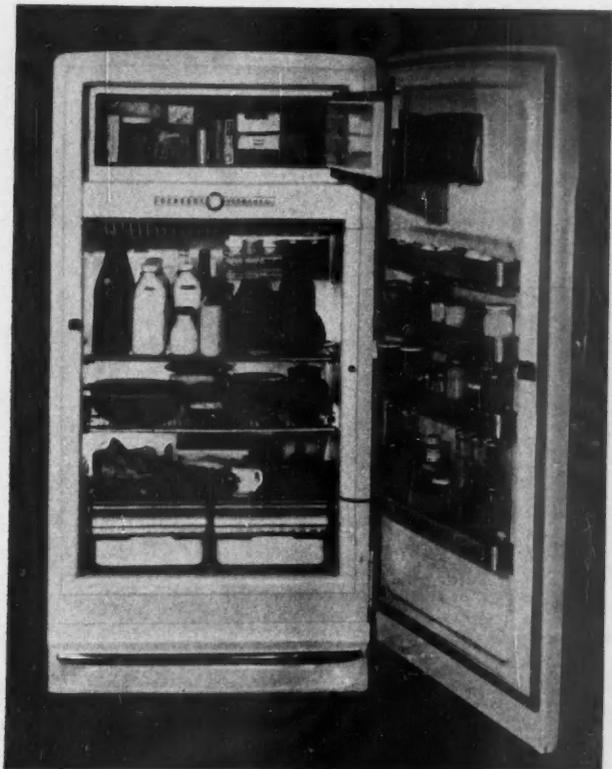
Two of the new combination units are the single-door type with a 9.5-cubic-foot capacity, and a separate inside door with gasket and trigger-action latch to seal off the freezer compartment. The third is a two-door type with an 11-cubic-

foot capacity. In all three combination units insulated compartments for frozen foods and fresh foods are separately refrigerated. And a newly designed refrigerating system provides zero-range temperatures for frozen foods, and a moist, cold temperature for fresh foods.

Defrosting of the freezer compartment is required only a few times a year, and frozen foods can be safely stored up to periods of one year. In the fresh-food compartment a downward-tilted refrig-

erated coil defrosts automatically, without the use of heaters or timers, after each running cycle.

The two fully automatic refrigerators have directed cold-air circulation throughout the fresh-food section. They are single-door models having an 8.7-cubic-foot capacity and a side-hinged latched door on the across-the-top freezing compartment featuring a new defrosting system. Whenever defrosting of the evaporator is necessary, a frost-



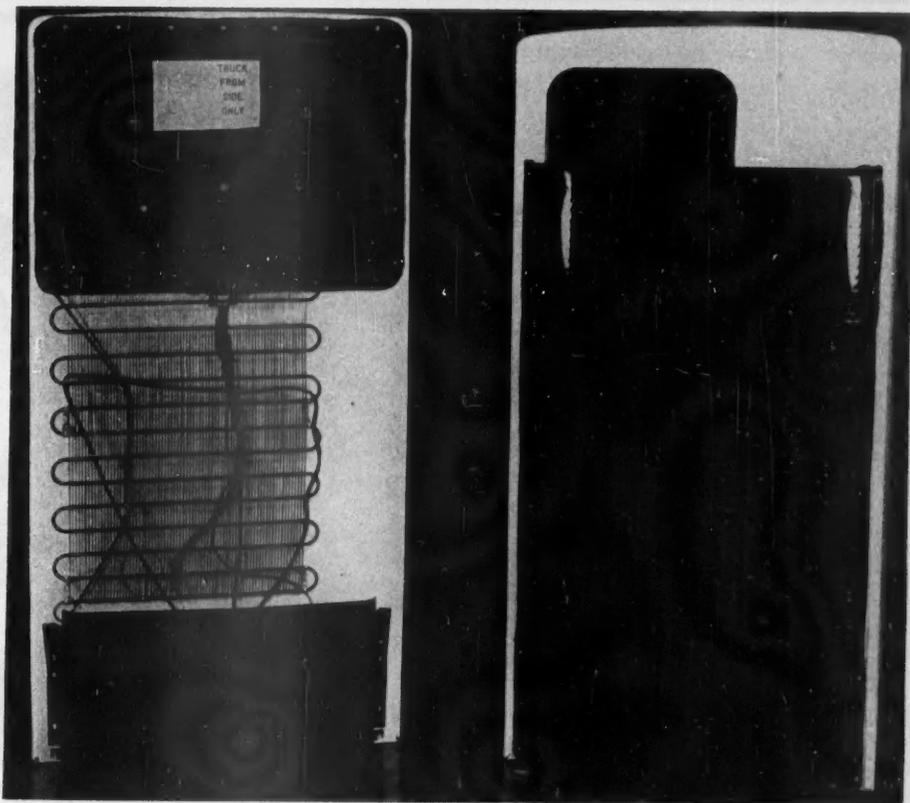
COMBINATION refrigerators are of 9.5-cubic-foot capacity (above) and 11-cubic-foot capacity (above, right).

The separately insulated compartments for frozen foods and fresh foods are separately refrigerated. The newly designed refrigerating system provides zero-range temperature for frozen foods and even, moist cold for fresh foods.

The freezer compartment is made of aluminum and refrigerated at the top as well as at the back and on the bottom. Defrosting is required only a few times a year.

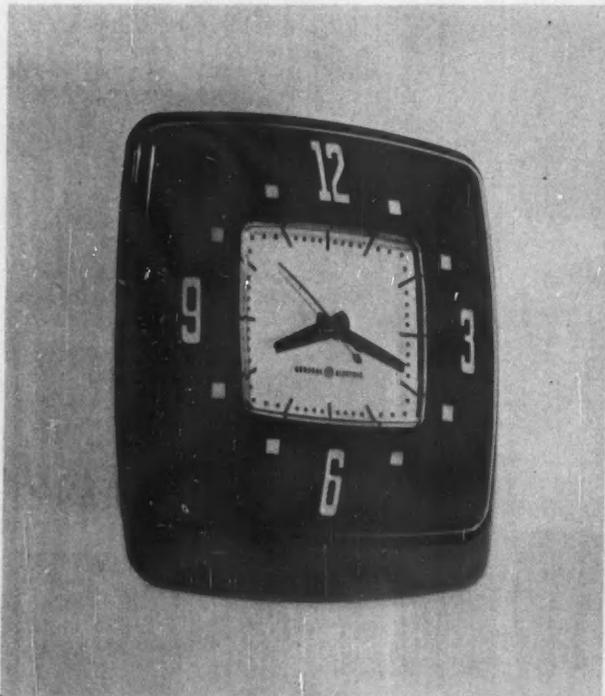
The fresh food section has a downward-tilted refrigerated coil located at the top. This coil defrosts automatically, without use of heaters and timers, after each running cycle. The defrost water runs down the coil to the back of the cabinet where it is channeled to an evaporating pan in the base compartment.

Another new development is the wire condenser (right) that transfers heat as well as its plate-and-tube predecessor (extreme right) and costs only 62 percent as much to manufacture





ALL-PURPOSE FAN ALSO FUNCTIONS AS WINDOW VENTILATOR. PORTABLE ELECTRIC MIXER WEIGHS ONLY THREE POUNDS, HAS TWO SPEEDS



"CONTOUR" KITCHEN CLOCK APPEARS TO FIT SNUGLY AGAINST WALL. "ORIGINALITY" HAS NUMERAL RING SPACED AWAY FROM CASE

limiting device turns on a 330-watt sealed heating unit. It combines the effects of door openings and the air's moisture content, and thus adjusts itself to varying climates and usage.

All of the automatic-defrost refrigerators and three of the four manual-defrost refrigerators have aluminum freezer compartments. These compartments are refrigerated at the top as well as the back and bottom sides. Shelves are made of nonrusting anodized aluminum.

Dishwashers

General Electric dishwashers now incorporate a new control mechanism that makes it possible to repeat, skip, or interrupt any stage in the dishwashing cycle. The mechanism permits double washing of heavily crusted pots and pans, fast washing of lightly soiled glassware, and the preheating of plates for serving hot food. Other features of the dishwashers are greater capacity— $1\frac{3}{8}$ inches in depth was added—and a restyled front and control panel.

Home Laundry

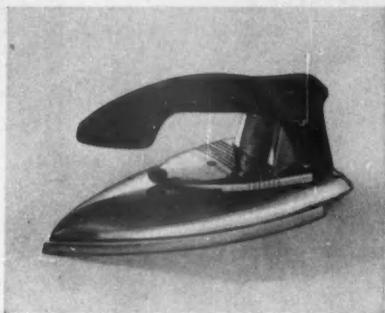
Three new wringer washers—deluxe, medium-priced, and low-priced—were included in the new line of home laundry equipment. Features of the deluxe model are a timer that controls the wash period up to 15 minutes and an "instinctive wringer." All were restyled for appearance and incorporate various improvements.

Also included in the new line are two automatic washers and a clothes dryer. Both washers accommodate nine pounds of assorted dry clothes. They are top-loading, free-standing machines that require no bolting or reinforced floors for installation. The automatic clothes dryer capacity equals the average washer load of nine pounds. Operating on 220 volts, it dries any washable woven fabric at the proper heat level.

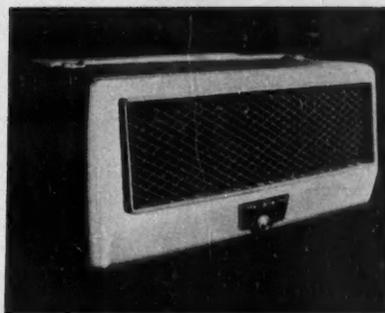
Ironers for 1953 include two types: a portable rotary ironer, and a pedal-controlled automatic flatplate ironer.

Food Freezer

A seven-cubic-foot chest-type food freezer developed during the year provides the highest volume per unit of floor space in its size classification. One of three new models, it reflects the trend toward greater kitchen placement. A 14-cubic-foot upright freezer—the first of its kind built by General Electric—provides ease of installation and greater



TRAVEL IRON WEIGHS $1\frac{1}{2}$ POUNDS. AIR CONDITIONER GIVES EVEN ROOM TEMPERATURE



accessibility of contents. It has unusually low power requirements—half as much as some models operating under equivalent conditions. An 11-cubic-foot chest-type model completes the line. All three machines utilize a natural-draft wire-and-tube-type condenser.

Room Air Conditioner

Current models of room air conditioners now include a thermostat control with a two-to-three-degree temperature differential. Sensitive to the air stream entering the unit, the thermostat maintains more constant temperatures within the room.

All-purpose Fan

A new all-purpose household fan was developed during the year that can be used as a desk or table fan, a window ventilator, or a floor circulator. Its self-aligning blades are mounted on a sturdy rubber hub, and a handy opening in the back grill provides quick portability from room to room. Regulated by a two-speed switch, the air flow is concentrated and directed by a metal orifice for greater efficiency. The fan is rated at 85 watts, and has an air flow of 1050 cubic feet per minute at a velocity of 1300 feet per minute.

Portable Mixer

A new portable mixer weighing only three pounds is readily adaptable for use in any part of the kitchen. Adjustable to high or low speed by a finger-tip control, it is used with one or two beaters. Like an electric iron, the mixer stands by itself on a special heel rest.

Travel Iron

A $1\frac{1}{2}$ -pound completely automatic travel iron operates on either a-c or d-c. It has a special dial-the-fabric control. When not in use, the handle folds down

and the appliance slips neatly into a carrying case. Double thumb rests permit right- or left-hand use.

Clocks

New appearance with added features for consumer appeal was the keynote of 1952 clocks.

Contour, a General Electric kitchen clock, appears to fit snugly to the wall with a minimum of visible thickness. A snap-locked easily removable polystyrene crystal with numerals heat-stamped on the inside surface facilitates cleaning. The clock's movement is set—without removing it from the wall—by manually rotating a nonvisible setting-wheel that extends through the side, near the back portion of the case.

Originality, a kitchen clock developed by the Telechron Department of General Electric, includes a cord slot to permit excess lengths of electric cord to be recessed in the back of the clock. A numeral ring spaced away from the case appears to be detached from it. The effect is obtained by using a clear polystyrene disc that is attached to the case and numeral ring. The design is such that the parts are molded in single-action injection molds without side core motions.

Radio Timer

A basically new radio timer for use in clock radios allows the radio-cabinet designer more freedom for variation and provides the user with greater simplicity of operation. A small pointer is used for setting the hour at which the radio is turned on, and there are two setting knobs on the front instead of the customary three. All functions of the alarm set and auxiliary buzzer signal are controlled by one knob. Operation of radio-switching circuits is controlled by the other. Ω



FORD MOTOR COMPANY OFFICIALS INSPECT THE INTERCHANGEABLE UNITS OF THE . . .

New G-E Motor Control Center

Since January, over 10,000 men from production and management of leading industries (see above) have taken a thorough look at the latest equipment for the centralized control of a-c motors up to 200 hp. Their reports indicate enthusiastic approval of what they saw. Here's why:

VERSATILE. Because units are easily interchangeable without waste space, a variety of arrangements can be made. For example—two Size 1 or 2 starter units require the same space as a Size 1, 2, or 3 reversing starter.

ACCESSIBLE. A four-inch continuous wiring trough provides ample wiring

space. Components are mounted on an easy-to-handle frame and accessible from all sides when lifted from cabinet. Starters are front-connected. Master terminal boards can be swung out of compartment for extra working space around conduit.

PROTECTED. Will withstand 25,000 amperes RMS short-circuit current, substantiated by certified Laboratory tests.

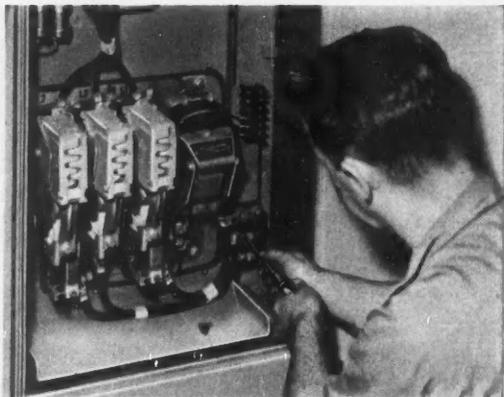
For more information on this new G-E motor control center, contact your nearest G-E apparatus sales office or write for Bulletin GEA-4979A today. *General Electric Company, Schenectady 5, N. Y.* 730-42



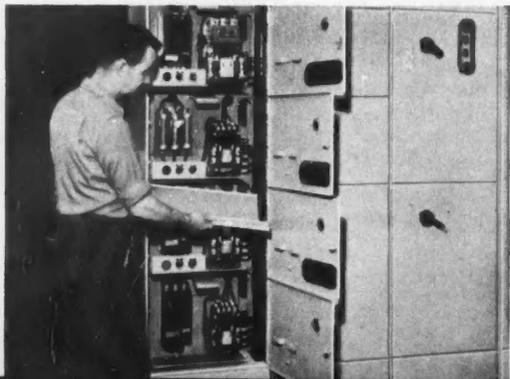
EASY TO INSTALL AND INSPECT. Interchangeable units; main bus completely accessible; incoming line connections are easily made.



EASY TO WIRE. Four-inch wiring trough; components accessible from all sides; front-connected starters; doors swing more than 90°.



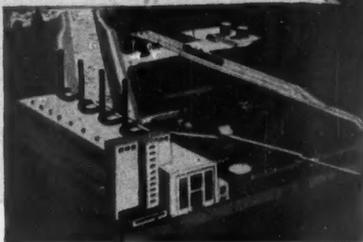
EASY TO SERVICE. Units are easily disconnected from bus and locked in test position (above). Barriers between units are easily removed to facilitate wiring (below).



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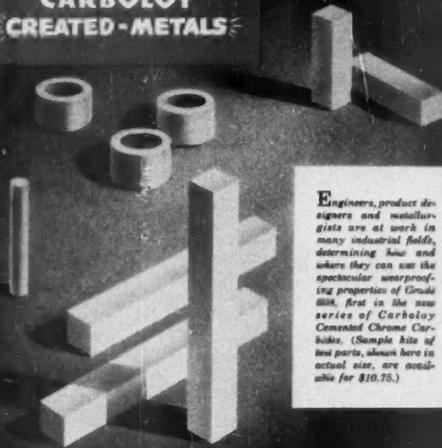
It's the biggest news in kitchen equipment in years! G-E Textolite MONOTOP surfacing, a brand-new contribution of General Electric chemical progress, is a counter top and backsplash *molded in one piece!* The "no-drip" lip keeps spilled liquids from running down cabinet fronts and there are no cracks or crevices in the unit to collect food particles or dust.

Other G-E contributions in plastics laminates include light-weight refrigerator "inner doors," many specialized parts for the electronics industry, and a complete line of laminated sheets, tubes and rods for a variety of industrial applications. Look to General Electric chemical progress for the latest developments in:

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Success stories of
**CARBOLOY
CREATED-METALS**



Engineers, product designers and metallurgists are at work in many industrial fields, determining how and where they can use the spectacular wearproofing properties of Elmholtz. First in the new series of Carboloy Cemented Chrome Carbide. (Sample bits of new parts, shown here in actual size, are available for \$10.75.)

Industry now testing new cemented chrome carbide for corrosion, abrasion, erosion

Starting right now! Here's the story of another new Carboloy created-metal born to succeed.

It's the story of the new Series 600 Carboloy Cemented Chrome Carbide, containing chromium as the principal ingredient and developed specially for high resistance to corrosion or erosion combined with good abrasion resistance. Grade 608, the first in this new series of chrome carbides (now available in test-sample quantities), promises famous carbide wearproofing benefits for whole new fields of industry.

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Perhaps there is a Carboloy metal with its wide range of advantages that you can use. Carboloy Cemented Tungsten Carbide for more efficient cutting tools, dies, or wear resistance, for example. Or Carboloy Alnico permanent magnets to incorporate in a product and improve

its design, lower its cost. Or Hevimet for a better balance weight or radioactive radiation screening.

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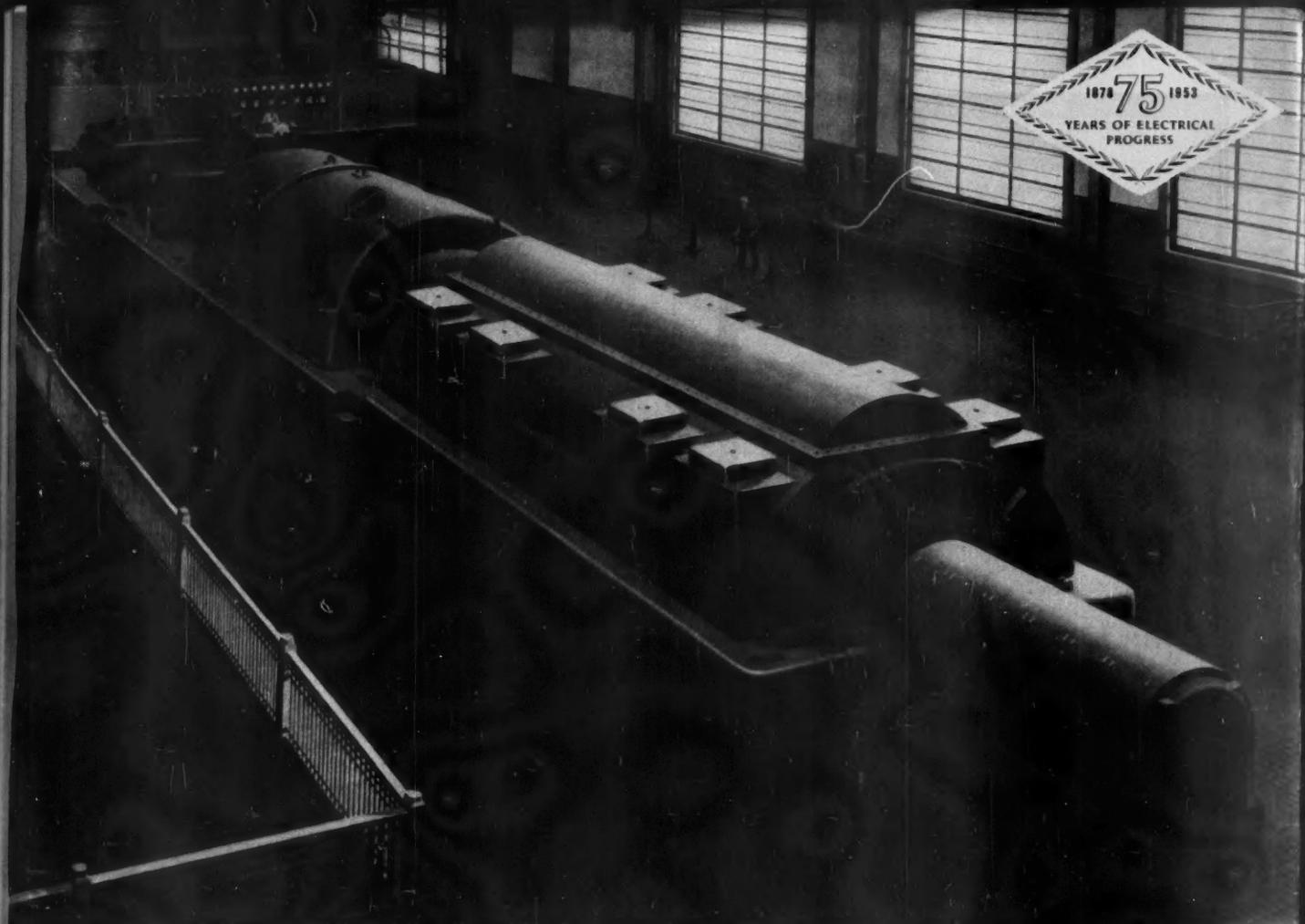
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Waukegan Generator Advances Trend To Larger 3600 RPM Capacities

An important phase of the utility industry's drive towards greater power production economy has been the trend towards larger 3600 rpm generator sizes.

A significant advance was made at the Waukegan station of the Public Service Company of Northern Illinois in December, 1951, when a new turbine-driven generator, at that time the largest of its type, was put into service. This General Electric generator, rated 129,412 kva, 85%

p.f. at $\frac{1}{2}$ lb hydrogen pressure (or 148,824 kva, 81.3% p.f. at 25 lb hydrogen pressure) has turned in a trouble-free operating record, well within its performance guarantee.*

Because of its size and characteristics, the unit provides its owners with high efficiency at a relatively low capital investment per kilowatt capacity. For the electric utility industry, the Waukegan machine helps point the way towards higher pressure, higher-temperature reheat units,

operating at high rotating speeds.

Despite its size, this machine does not mark a departure from General Electric's standard methods of design and manufacture. For example, a long established, service-tested system of ventilation was used. In fact, 96 additional generators of equal capacity or larger, employing standard design, are in various stages of manufacture. General Electric Company, Schenectady 5, N. Y.

*The generator is driven by a turbine with a nominal rating of 110,000 kw.

254-5

You can put your confidence in—
GENERAL  ELECTRIC