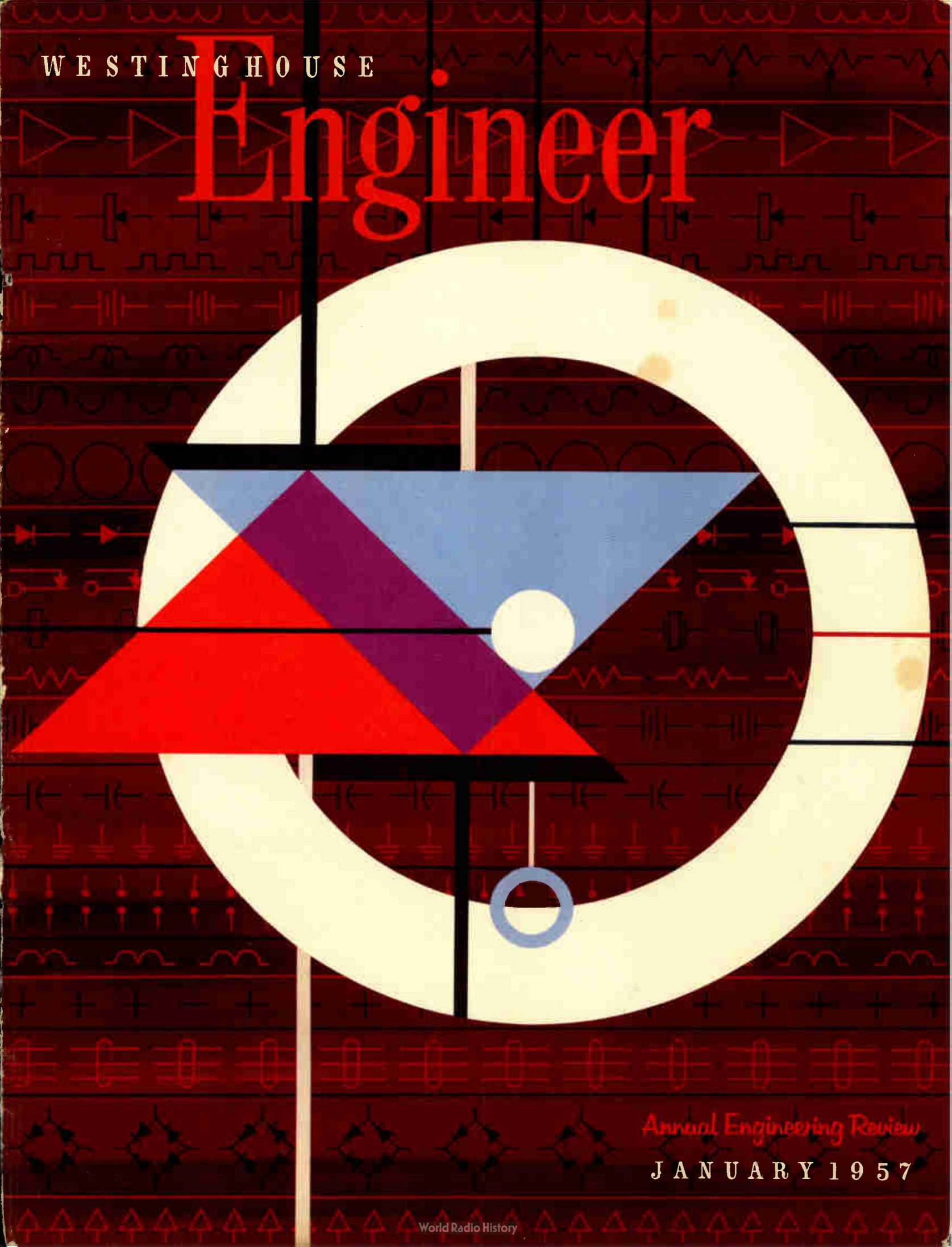
WESTINGHOUSE

Engineer



Annual Engineering Review

JANUARY 1957

WESTINGHOUSE

Engineer . . .

ENGINEERS SELDOM PAUSE TO REFLECT on their accomplishments, except momentarily, because there is always another step to be taken, an even more interesting or rewarding area to be explored. By and large, perhaps this is an American trait—to look to the future instead of the past. But there are things to be gained, things to be learned, by an occasional review of the past as well.

This review, as in previous years, is primarily one of the past year's scientific and engineering accomplishments at Westinghouse. We are indeed proud of the progress made even in this brief span. In research we have made great strides in developing a new light source, electroluminescence; and we are also making great progress with a new system of amplifying light, which gives promise of enabling man to see further into outer space than ever before. Atomic power continues to make dramatic progress. And new devices and systems of many varieties continue to appear for industry.

But as you read of these advances, we hope you will also be impressed—as we are—by the effect of these advances in the longer range view. The engineering progress made in one year is truly remarkable, but the full scope of technical progress and the rapidity with which it transpires are even more apparent when we consider several years. For example ten years ago, in the January 1947 review, we spoke proudly of a 105 000-kw turbine generator then under construction and a 100 000-kva power transformer shipped during the previous year. This year

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Annual Engineering Review

this same apparatus is over *three times* as large. And as the engineers involved could tell you, this increase in size is hardly as simple as scaling up components. Ten years ago a large-scale, power-producing nuclear reactor was but a dream. No one really had a good concept of even the problems involved. Today, several are reality and many more are being developed or constructed. This same degree of progress is evident in countless other fields. Known principles have been markedly improved, and many new concepts and devices have appeared that were unheard of—or even undreamed of—ten years ago.

This quickening pace, plus the increasing complexity of technology, also means that engineering is becoming more and more of a team effort. Few, if any, of the developments described in this issue were the result of one man's efforts. The question is not so much that more than one man's intelligence and ingenuity are required, but that more than one technical background is needed on a given development. Increasingly, the hand of the physicist, the chemist, the metallurgist, can be seen in developments.

Any engineering review such as this can serve several purposes. We hope you find it interesting, not only as a review of current Westinghouse developments, but also as a reminder of the tremendous technical progress being made in the nation.

J. A. HUTCHESON
Vice President, Engineering

The Cover

Every profession has its own language. In engineering the symbols used in constructing circuit diagrams are in themselves an alphabet. On this month's cover, against a pattern of many symbols, artist Dick Marsh has woven an intricate pattern of three of these symbols—a rectifier, a centrifugal regulator and a wound-rotor motor.

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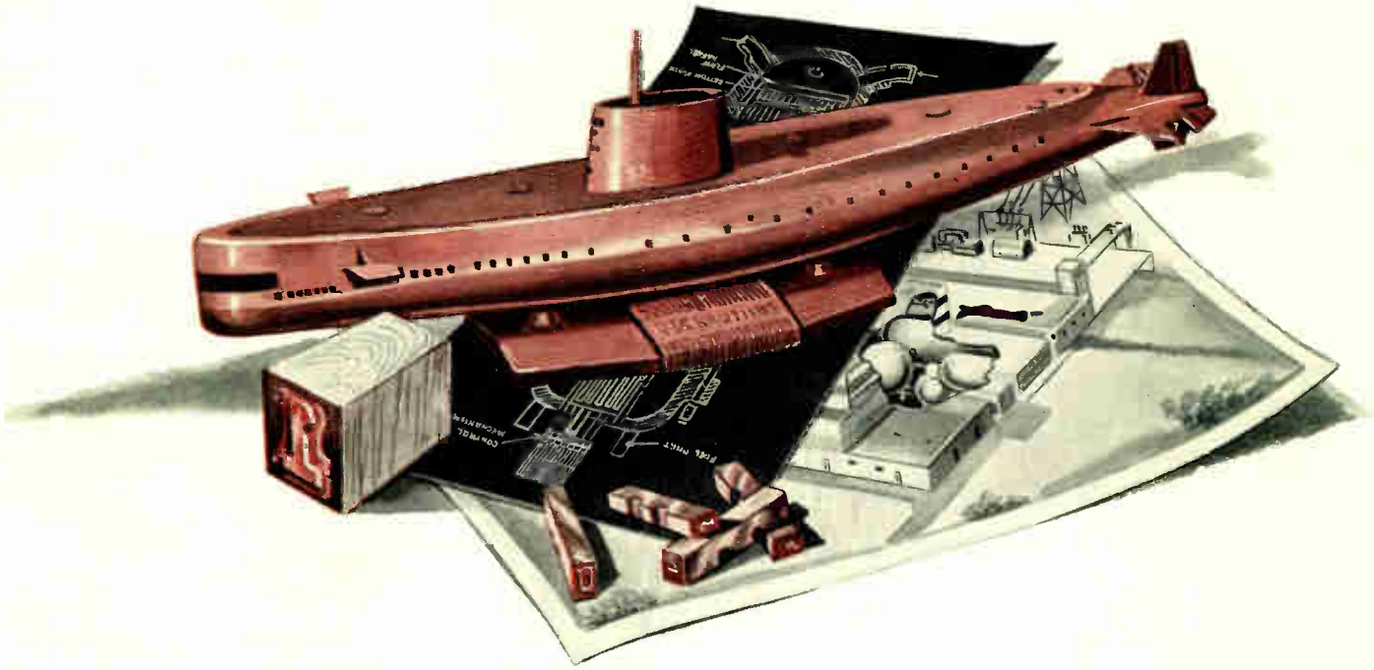


Atomic Power

■ The taming of the atom continues to be an almost fantastic story. Consider. Few thoughts were directed toward the possibility of controlled power from the atom until after World War II, and certainly no well-defined steps were taken in that direction until 1946. The period from 1946 to 1948 was a formulative stage; ideas began to take recognizable shape, and scientists and engineers discussed and evaluated various ways in which useful power could be obtained in large quantities.

In 1948 came the first project aimed specifically at a large power-producing nuclear reactor, an event marked by the announcement by the Atomic Energy Commission and the Navy that Westinghouse would build a power reactor for a naval vessel. This was a project filled with unknowns, since it was the first attempt to build a large-scale power reactor. There was little or no background of experience upon which to draw. There were few engineers and scientists who knew the first thing about atomic power. Yet four and a half years later a power reactor produced the first substantial quantity of controlled power from the atom. This reactor was the prototype of the power plant for the USS *Nautilus*, and it was located in a section of a ship's hull in the Idaho desert.

This was but three and a half years ago, in May, 1953. Yet today, power reactor projects are sprouting everywhere. Many different types of reactors are being designed; several are now under construction. All this in less than ten years! If proof is needed of the accelerating pace of technology, one need look no further than the field of atomic power. ■

Nuclear Power for Ship Propulsion

Ship Propulsion

■ Dramatic evidence of the far-reaching effects of nuclear power on ship propulsion came with information announced in 1956 by the Atomic Energy Commission and the Navy. The first came when the Navy released cruise figures for the first atomic submarine, the *Nautilus*. As of September, the *Nautilus*, powered by a Westinghouse nuclear plant, traveled over 47 000 nautical miles without refueling. Just over half of this distance, or a little over 27 000 miles, the submarine steamed totally submerged. On her shakedown cruise in 1955, the *Nautilus* made the 1300-mile run from New London to San Juan, Puerto Rico totally submerged at an average speed of over 16 knots. This was ten times as far as any submarine ever traveled submerged, and the first time any submarine had maintained that speed for more than an hour.

The second important announcement came in August, released by the Atomic Energy Commission. This dealt with the "successful conclusion of an unprecedented power demonstration by an atomic ship propulsion reactor". This reactor was the land-based prototype of the *Nautilus* plant, originally called the Mark I, now designated the S1W. On August 8, 1956 the reactor was routinely shut down after what is believed to be the longest full-power run ever completed by any type of propulsion plant—land, sea, or air. For 66 days and 66 nights the nuclear reactor operated at an average power of 100 percent—meanwhile using only part of its uranium fuel charge. The test was designed to prove the reliability and stamina of pressurized water reactors for ship propulsion. Out of this test came invaluable and heretofore unavailable information on reactor performance during extended high power runs—information that can be used in developing future designs.

A few figures illustrate the significance of the test run. If the *Nautilus* herself had made a cruise for this length of time—some 1600 hours—she could have steamed at top speed, submerged, around the world and continued on for many thousands of miles more. Such a cruise by a diesel-powered submarine of similar power would have required about 1 600 000 gallons of

fuel—or about enough to fill 160 railroad tank cars.

The success of this new concept in ship propulsion has led to further atomic submarine development. Among the projects now underway are several nuclear plants to be built by Westinghouse. One project is to design and construct reactor power plants for five fleet-type submarines; this project is called SFR.

Work is now also underway on a complete atomic power plant for installation in one of the Navy's new high-speed hulls. This power plant, designated the S5W, will be installed in a submarine patterned after the *Albacore*, an experimental, conventionally powered sub.

Nuclear-powered surface ships are also coming in for their share of attention. The Large Ship Reactor Project, now known as the A1W, is well underway. Design and development work by Westinghouse has been proceeding at the Bettis plant in Pittsburgh. This year construction work on the prototype plant began at the Naval Reactors Facility in Idaho.

A nuclear-powered aircraft carrier was also announced by the Navy in late 1956. Reactor compartment components will be designed and furnished by Westinghouse. This aircraft carrier will be propelled by eight pressurized-water reactors.

A second surface ship project, announced by the Navy in 1956, was for a nuclear-power guided-missile light cruiser. Reactor compartment components will be furnished by Westinghouse. The vessel will be fitted out with the most advanced armament and guided missiles available for fleet use.

In the two short years since the *Nautilus* backed into the Thames River and flashed its historic message "Underway on nuclear power," tremendous progress has been made. Its value already dramatically demonstrated, nuclear power for ship propulsion is moving ahead, with these and other AEC and Navy projects, to even more remarkable and significant results. ■

Atomic Power for Electric-Utility Plants

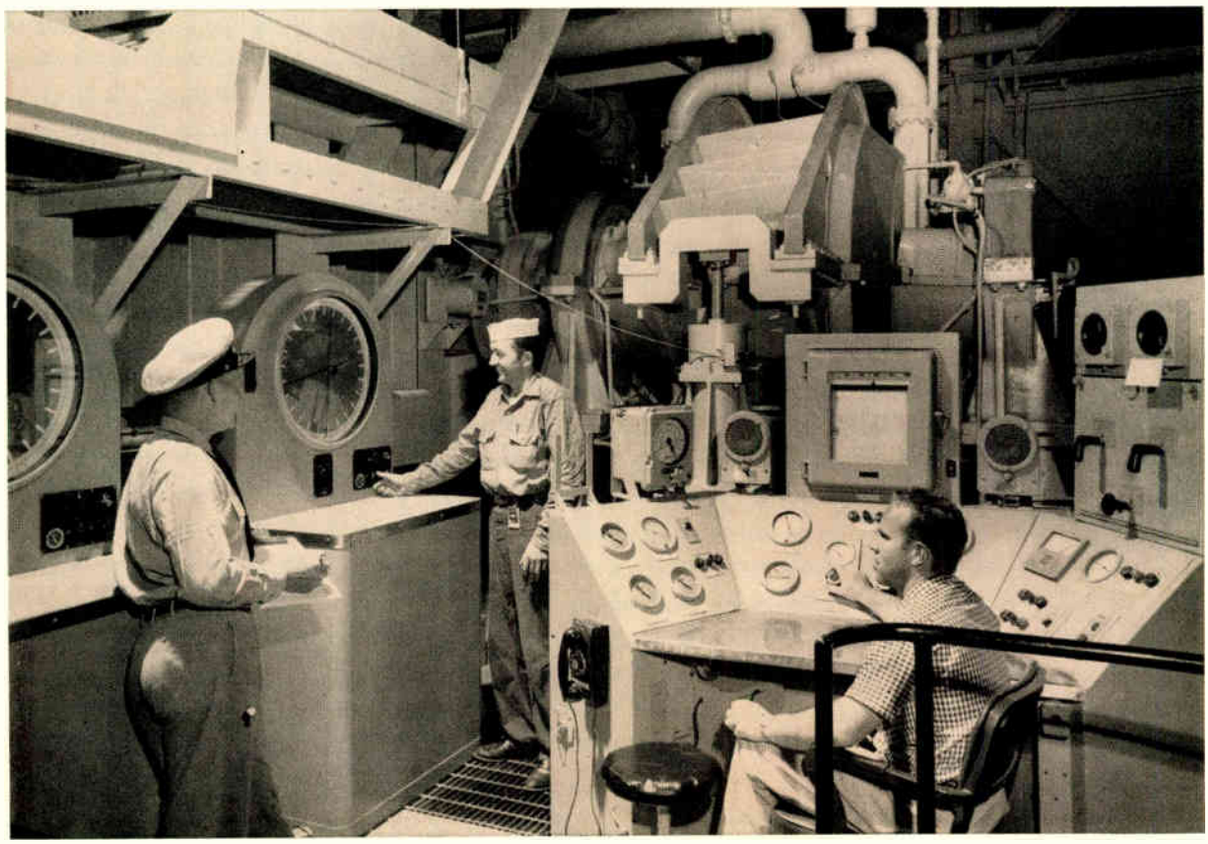
Electric Utility

■ Atomic-power plants for electric-utility use are progressing swiftly. Construction of the nation's first full-scale nuclear-power generating station at Shippingport is moving along rapidly. Steel work and placing of concrete is nearing completion. Many of the major components of the plant loop were completed and installed by the end of 1956. The entire plant is scheduled to be finished in 1957.

Duquesne Light Company is building the turbine-generator portion of the plant, and will operate the entire station when it is completed. Westinghouse, under contract to the Atomic Energy Commission, is designing, developing, and constructing the nuclear portion of the station.

The Shippingport station, with a capacity of at least 60 000 kw of electricity, is not intended to produce economic power; it will make possible firm cost estimates for the future and provide design and technological experience obtainable only from full-scale plant operation.

During 1956, a second contract was awarded to Westinghouse for the development of a pressurized water reactor using stainless-steel-clad fuel elements —this for the Yankee Atomic Electric Company. Yankee Atomic, formed by 12 of the major electric-power companies in New England, is building the plant under the provisions of the Atomic Energy Commission's Large Power Reactor Demonstration Program. Under the terms of this program, the de-



U.S. Navy nuclear-submarine trainees operate mechanical brake that measured output of submarine atomic power plant during what is believed to be the longest full-power test ever attempted by any propulsion plant. Test was conducted by the AEC in the testing station in Idaho.

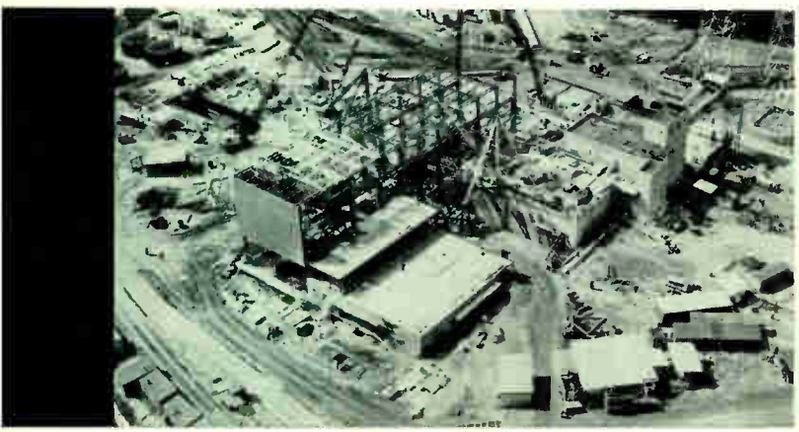
velopment work on the reactor core will be financed by the Commission.

Although this is also a pressurized-water reactor, the nuclear portion of this new 134-mw plant differs from the Shippingport station in many respects. Pressures and temperatures for the primary loop will be roughly the same as for Shippingport. However, stainless steel will be used instead of zirconium for the tubes that contain fuel; fuel itself will be slightly enriched uranium, instead of the so-called "seed and blanket" design of the PWR. Heat output to produce the 134 mw of electricity will be about 480 mw.

A radically different concept is now being developed by the Pennsylvania Power and Light Company and Westinghouse. This is a homogeneous reactor, in which the fuel is in the form of a slurry rather than a solid material.

The decision to build this type of reactor for a new 150-mw atomic plant was announced in July, 1955. Since that time considerable investigation has been carried out concerning the general problems associated with such a plant.

The work on this project—called the PAR project—is in two phases. Phase I, now in progress, is primarily aimed at developing the knowledge and the know-how necessary to produce a plant design. Basically, this involves making several reference designs to discover where the present and potential problems are, and concurrently conducting test programs on various known problems. From these reference designs and the concurrent testing programs will come the information on which the final design will be developed and built (Phase II).



A view of the Shippingport nuclear-power station taken during construction phase in 1956.

As an indication of the approach, the first reference design involves a homogeneous reactor utilizing a slurry of thorium and uranium oxides and heavy water, the latter serving as moderator and coolant. Basically the reactor system would consist of the reactor itself, a gas separator, steam generator, a primary pump, and necessary valving. Associated with the loop would be various auxiliary equipment, such as a surge chamber and pressurizer, and reprocessing means. For this theoretical reactor, slurry would enter the reactor at 465 degrees F and leave at 580 degrees. About 550 megawatts of heat would be developed in the reactor.

With such a theoretical design—in more detail, of course—various factors can be investigated, both in general and as they apply to the specific reference design. For example, several slurry loops have been in operation, and have completed several 1000-hour runs. These pump slurry in a closed loop and through test chambers, where the erosion and corrosion effects of the slurry can be determined under various conditions of operation.

Many of the problems faced with this homogeneous reactor bear little resemblance to those of the pressurized-water reactor. For example, since the fuel itself circulates throughout the primary loop, as contrasted to just water in solid-fuel reactors, radioactivity and its effects are far greater in the portion of the loop outside the reactor. The effects of radiation on the various loop components must be carefully considered. Also, because of radioactivity, any maintenance or repair of loop components will have to be accomplished by remote or semi-remote means. Thus it is doubly important that they be as reliable and as maintenance free as possible.

Many factors remain to be evaluated before a final system design can be made; at the same time, however, much progress has been made to date and no insurmountable roadblocks have been found.

While large reactors have attracted much of the attention, small atomic power plants are also in the news. One example is the Belgian Thermal Reactor (BTR), being built by Westinghouse for the Syndicat d'Etude de l'Energie Nucleaire, a Belgian nuclear-energy society. This power plant—the first marketed abroad by an American corporation—will use a pressurized-water reactor with a heat output of 43 000 kw. Gross electrical output of the plant is 11 500 kw. Primary pressure is 2000 psia and steam is produced at 520 psia. The reactor vessel is approximately 18 feet high and five feet in diameter. Coolant enters the reactor vessel at 492 degrees F and leaves at 518 degrees. The temperature rise of 26 degrees F dictates a total flow of five million pounds per hour to transmit the reactor heat of 43 000 kilowatts, or 147 million Btu per hour.

A new Westinghouse Testing Reactor will be the first privately financed test reactor in the country. Initial operation will be at a power output of 20 megawatts, but the plant is designed for an ultimate capability of 60 mw. The WTR is designed primarily for studying the physical characteristics of materials exposed to high levels of radiation; when completed it will be available to both Westinghouse and other companies for studying these effects. ■

Equipment for Atomic Power Plants

■ Atomic power brought with it a whole host of new problems for equipment designers. Although many of the functions performed by equipment associated with atomic reactors are familiar ones, i.e., pumping, valve control, etc., the conditions under which the components must live and their standards of performance necessitate a whole new design approach.

Consider, for example, the problem of pumping the coolant through the primary loop of a pressurized water reactor plant. Several major problems are immediately apparent. First of all, the hot-water coolant

is an extremely corrosive agent. Thus everything in contact with the water must be extremely inert, to avoid introducing foreign particles into the coolant. Also, the components must be a hundred percent leakproof; the usual types of packing and gasketing cannot be relied upon for this requirement. Add to these the fact that the pumps must operate for long periods of time without periodic inspection and the size of the problem comes into focus.

To satisfy this pumping requirement, several years ago Westinghouse developed a "canned" motor-pump. From this has grown a family of similar pumps. These are hermetically sealed, and have no external shaft seal. Suction and discharge nozzles are designed to be welded into the pipeline. Pumped fluid is allowed to circulate in the motor cavity, but is excluded from the rotor and stator windings by corrosion-resistant sealing cans.

The largest canned motor-pump ever built, the first of four for the PWR plant at Shippingport, has undergone rigorous performance tests. This is a 1600-hp motor-pump that will circulate 18,300 gpm or more of radioactive water through the primary loop of the reactor system, which is at an ambient of approximately 2000 psi and 500 degrees F. The pump uses a 1200-kw, 2300-volt single-winding motor that is connected for two speeds. This is a zero leakage pump.

A new counterpart to this water pump is a hermetically sealed mechanical liquid-metal pump, developed last year. Designed to circulate liquid sodium or sodium-potassium alloy, the new pump can be applied to nuclear-power plants, or to chemical process lines or similar applications requiring high-temperature heat-transfer mediums. Sizes up to 4000 gpm for fluid temperatures as high as 1500 degrees F have been developed and manufacture has begun.

Motor windings are protected from the heat of the fluid by several means. Conduction of heat from pump to motor is reduced by an air-cavity thermal barrier. Stator windings are protected from the heat in the magnetic gap by a wire-mesh thermal barrier between the stator can and stator laminations. Circulation of an externally supplied coolant—the only auxiliary requirement—completes the cooling means. Double walls are provided between the coolant and the sodium at all points of the integral heat exchanger. The net effect of these cooling effects is that the pumped fluid temperature has little effect on the motor winding temperature; thus winding insulation does not limit the temperature of the pumped fluid.

During 1956 a small version of this pump—rated at 150 gpm at a 285-foot head—completed a successful 1500-hour performance run at more than 1000 degrees F—the highest temperature at which a pump of this type had ever operated for an extended period.

Valves for reactor-loop use also offer unique design problems. Common types of valves are operated by some mechanical means attached to a shaft leading out of the valve body. The shaft is sealed with some sort of packing. For nuclear-loop purposes, this just doesn't work—at least with present packing materials. The 100-percent leakproof requirement can't be guaranteed. As a result, the valve must be completely enclosed, yet permit mechanical operation from outside.

Two methods are used. One is hydraulic operation of a piston, the other is magnetic control of an armature. The hydraulic system, while more cumbersome, lends itself readily to the operation of large valves. A small canned pump raises a small amount of control fluid to a pressure slightly above that of the system. This control fluid is introduced above or below the piston to operate the valve in the desired direction. This higher pressure fluid is controlled by a small solenoid-operated valve. Quickly reversible pumps for the control of piston-operated valves without solenoid control valves are under consideration.

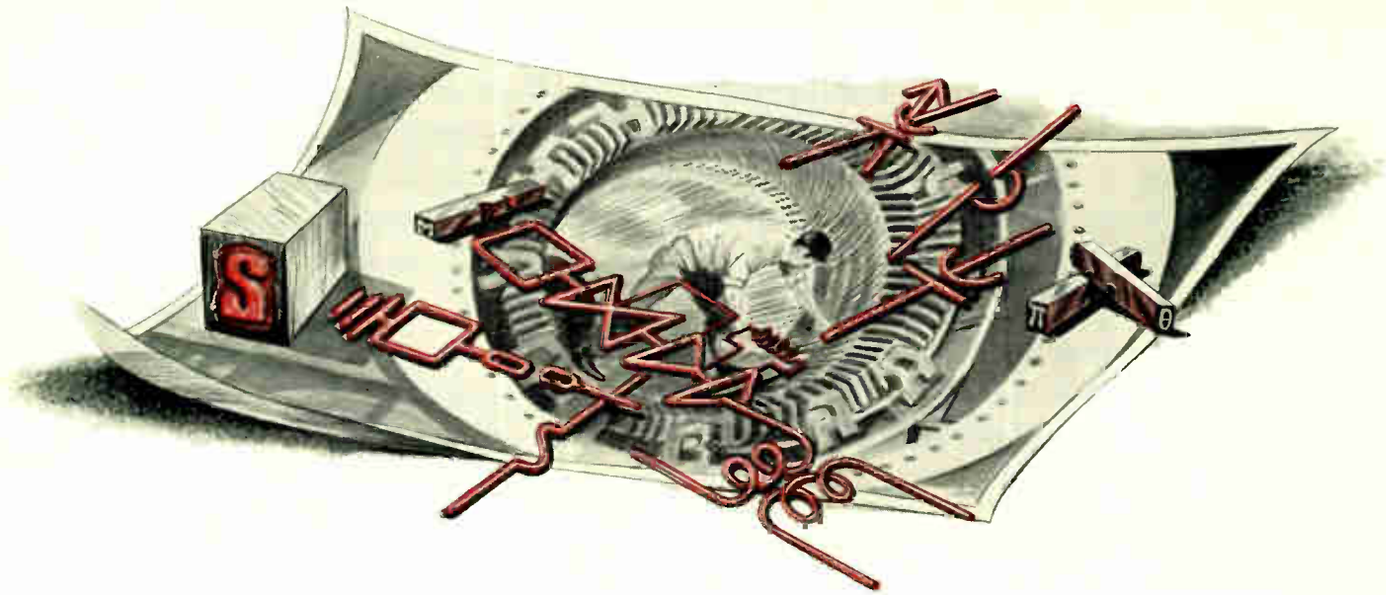
With electromagnetic control, a high-temperature coil operates a plunger in a hermetically sealed chamber. The plunger either operates the valve stem directly, or functions as a pilot that allows system pressure to operate the valve. The hermetically sealed container holding the plunger must satisfy two conflicting requirements. Since it is part of the valve it must be capable of withstanding system pressure and temperature; but at the same time the walls must be thin as possible since they are in the magnetic gap.

Design conditions for both the hydraulically and electrically operated valves is about 3000 psig at 600 degrees F. A variety of different valve designs have been evolved for pressurized-water systems, ranging in size from ½ inch to 18 inches.

An outline of all the problems encountered in developing equipment for nuclear power use would fill an extensive set of volumes. These examples of two devices to fill common functions—pumping and valve control—are merely suggestive of the myriad of problems faced and overcome. ■

Plant Equipment

These four canned motor pumps—the world's largest—will be installed as part of the Shippingport plant. Each is rated at 1600 hp, weighs nearly 14 tons.



Power Generation, Transmission, Distribution

Turbines and Generators

Progress In Inner Cooling

■ The first four-pole inner-cooled, 1800-rpm generator will be a part of the first 5000-psi super-pressure turbine-generator unit. Advantages that have already been gained in 3600-rpm, two-pole inner-cooled machines can also be realized for the 1800-rpm machine—greater electrical output is obtained for a given physical rotor size, which means smaller and more reliable forgings can be used; also, the inner-cooled machine provides greater electrical capacity at higher gas pressures than the conventional machine. This is because with conventional cooling, only the external surfaces are cooled, whereas with inner cooling, the heat is carried away directly from its source in the winding. For example, a 25-percent greater output can be obtained from an inner-cooled machine if the gas pressure is raised from 30 to 60 pounds. Total kva of the cross-compound 5000-psi super-pressure turbine generator unit will be 416 000 kva; of this, the 1800-rpm unit will generate 231 000 kva, at 0.85 power factor.

An even larger 1800-rpm unit is now on order for the Consolidated Edison Company. This machine will have a rating of 330 000 kva at 45 psi gas pressure. It will be the largest single 1800-rpm unit yet built. The machine is for the nuclear power plant being constructed by Consolidated Edison at Indian Point, New York.

Two-pole, 3600-rpm inner-cooled units are managing to stay a step ahead in rating of their half-speed brothers; units three and four of TVA's Gallatin Station will have a capability of 364 000 kva at 60 psi gas pressure. This is about a 10 percent increase over Gallatin units one and two.

As of now, thirteen 3600-rpm inner-cooled machines have been shipped, twelve of which are in operation. The first inner-cooled unit, installed on the Niagara-Mohawk system, has completed nearly three years of service and the first Gallatin generator, the world's largest, has been operating for several months.

As the result of higher gas pressures, a new gland seal design has been developed. The seal keeps the cooling gas (hydrogen) inside, and the atmosphere outside. This is done by forcing oil against the rotor shaft so that hydrogen cannot escape. However in previous systems, the oil had to be continually vacuum treated to remove hydrogen, which had saturated the oil. The new gland seal has two pressurized oil systems, side by side; one seals hydrogen in, and the other seals air out. By utilizing two separate oil systems, the gas-side oil can be allowed to saturate with hydrogen. As a result, this component of total hydrogen gas consumption is practically eliminated. ■

Super-pressure Turbine Design Forging Ahead

■ Two years ago, when we first reported the super-pressure, 5000 psi steam turbine to be built for the Philadelphia Electric Company, designs were in the early stages and many details were yet to be finalized. Design engineers are now well along on the job.

When it goes into commercial service early in 1959, this 325 000-kw machine will be the largest capacity, highest pressure, highest temperature, and most efficient turbine ever built. Steam will enter the turbine at 1200 degrees F, 5000 psi; it will be reheated twice to 1050 degrees. The machine is a cross-compound unit; the super-pressure element is in tandem with a very-high-pressure and high-pressure element, operated at 3600 rpm; this unit is cross compounded with an intermediate-pressure element connected in tandem with two single-exhaust low-pressure condensing elements, all operating at 1800 rpm.

A second super-critical machine is now on order from the Cleveland Electric Illuminating Company. This one will have a guaranteed rating of 215 000 kw, with inlet steam at 1100 degrees F and 3500 psi, and a single reheat to 1050 degrees F. This turbine will all be on one shaft, a tandem-compound, triple-exhaust, 3600-rpm unit.

Problems Wrapped Up In A "Ball"—Actually, all of the new engineering problems for the super-critical turbines are in the spherically shaped, super-critical unit at the front of the machine. Once the steam leaves the super-critical turbine, it is at a temperature and

pressure in a much-explored area; from here on, the turbine-design is conventional.

The degree of thoroughness with which engineers are attacking the super-critical unit may be seen by considering the rotor, the heart of the unit. The rotor shafts for both super-critical units mentioned are similar in size and design; past experience has indicated that a single high-temperature forging should be used, which will be coupled to the very-high-pressure element. The super-critical shaft will be about 10½ feet long, 22 inches in diameter, and will weigh about 3500 pounds.

With the inlet steam close to 1200 degrees F, the rotor metal temperature will be about 1120 degrees F, a new high for rotor temperatures. Designers are therefore examining several possible materials to determine the most appropriate design.

The first material considered was Discaloy, a material developed by Westinghouse research and materials engineers for high-temperature jet-engine discs. A forging has been made (incidentally the largest forging ever made of this material) and is now undergoing study in connection with its heat treatment.

A second forging has been ordered from England, and is nearing completion. It is being supplied by William Jessop and Sons Ltd., a firm that has had notable success in making gas-turbine forgings for European use. If you are a metallurgist, the designation of the material, G-18-B, may be meaningful.

Then, a third forging of modified 12-percent chromium steel has been ordered. Philosophy in this instance was that although long life at the high temperatures involved could not be expected, it will give engineers a chance to further evaluate this material. The chromium-steel rotor could give limited-life service if necessary. The chief consideration here is that there must be a rotor ready for service when the machine is scheduled for service. At the somewhat lower temperature for the 3500-psi Cleveland machine, chromium steel could possibly give relatively long service life.

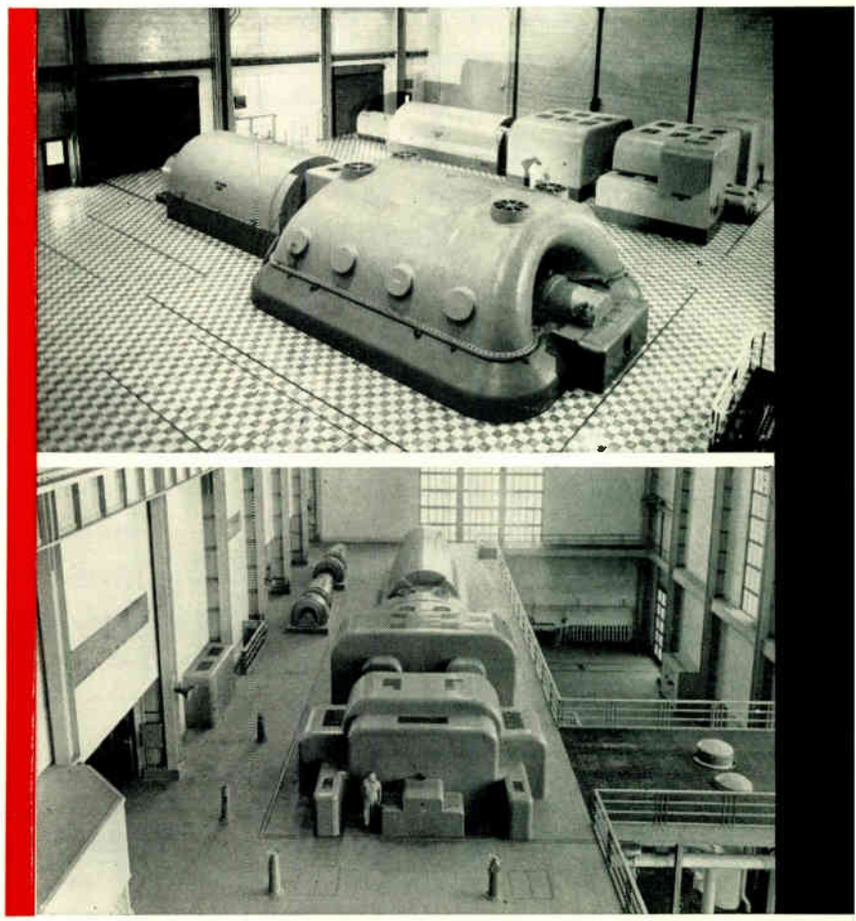
A fourth forging being tested is actually the chromium-molybdenum-vanadium steel of the type heretofore used for high-pressure steam turbines. This rotor appears suitable for the Cleveland machine, and could give limited life for the Philadelphia Electric machine. However, to make the test on this material most meaningful, the forging will be the first vacuum-poured steel forging; hence, it will be the best material of this type that is attainable.

Still another rotor of unique construction with shaft and separate discs, but assembled in a conventional manner, is being designed. This will give designers a chance to try another approach to the difficult rotor problem.

All rotors will be carefully tested. Each marks a significant step in the overall development program for high-temperature rotor materials. To assure each material a fair trial, only the best of each type is being tested. So this physically small turbine, which will develop about 44 000 kilowatts, or about ⅓ of the load on the 3600-rpm shaft, is getting lots of attention.

Speaking of Heat Rates—The most advanced steam conditions of any unit in operation were realized when the 200 000-kw unit went in operation in the Burlington Station of Public Service Electric and Gas Company in October, 1955. Steam enters the throttle at 2350 psig, 1100 degrees F; the turbine employs a single reheat to 1050 degrees F, and is a condensing machine. Most significant is the new low in heat rates, 8965 btu per kilowatt hour, obtained for the first full month's run. By comparison, in the most recent published ratings by the Federal Power Commission, the number one plant was the Kyger Creek Station of the Ohio Valley Electric Corporation, with a heat rate of 9110 btu per kilowatt hour. As a matter of interest four of the five installed machines at Kyger Creek are 225 000-kw Westinghouse units; the machines have steam conditions of 2000 psi, 1050 degrees F entering, with a single reheat to 1050 degrees F.

3600 and 3600—In steam turbines of conventional inlet steam pressures and temperatures, the usual practice has been tandem-compound, double-exhaust, 3600-rpm units for machines up to 150 000 kw; tandem-compound, triple-exhaust, 3600-rpm units are generally applied to ratings up to 225 000 kw; and cross-compound units utilizing 1800-rpm, double-exhaust, low-pressure element have been sold for ratings up to 325 000 kw.



One of the four 225 000-kw Westinghouse turbine generators operating at Kyger Creek Station.

This 200 000-kw unit was placed in operation in the Burlington Station in October 1955.

An exception to the previous rule is a new machine for the Bergen Generating Station of the Public Service Electric and Gas Company of New Jersey. This unit is of a unique design comprising of quadruple exhaust at 3600 rpm.

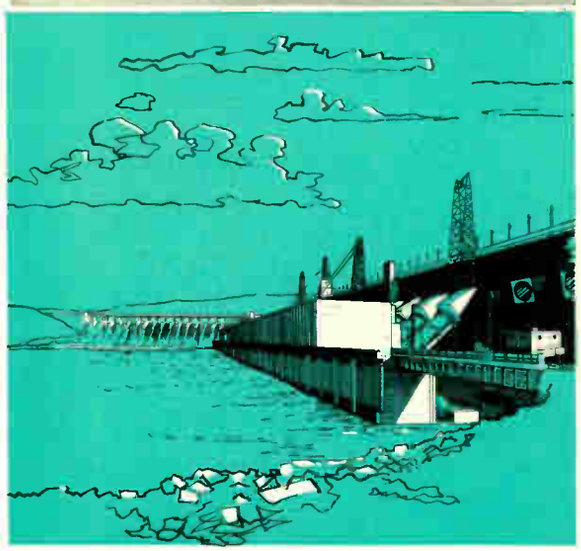
This new design permits the use of a cross-com-

pound 3600-rpm unit for ratings to 300 000 kw with steam inlet pressure of from 2000 to 3000 psig, and steam inlet temperatures of 1050 to 1100 degrees F.

A most important feature of the design is that by proper choice of the reheat pressure and the entrance pressure to the low-pressure ends, the load can be evenly split and nearly balanced over a wide portion of the operating range.

Another arrangement can be made using the triple-flow type of exhaust in parallel, thus giving a very large exhaust-end annulus, approximating the exhaust area now available with the largest double-flow 1800-rpm cross-compound design. With this arrangement, and the proper selection of inlet pressures and temperatures, even larger ratings can be realized.

A Westinghouse cross-compound, 3600/3600-rpm machine was put in service at the Burlington Generating Station of Public Service Electric and Gas Company in 1943. The newer design, with half the low-pressure turbine on each shaft, has shown advantages much superior to the older arrangement. It permits the use of duplicate generators, with balanced loads, and therefore a minimum of spare parts and accessory equipment need to be stocked. The new unit is scheduled to go into service in 1958. ■



These are the first four waterwheel generators installed at Chief Joseph Dam. Twelve additional units, each rated at 67 368 kva, are on order, to be installed within the next two years.

Distribution Transformer Progress

■ During the past year distribution transformers took several important steps in their evolution.

Transformers

Greater Overload Capability For Distribution Transformers—Functional life tests of complete transformers are now used to predict the load-life capabilities of distribution transformers. Such tests are much more accurate than tests of insulation samples alone.

Functional life testing, experience gained through years of applying CSP distribution transformers, plus a series of engineering improvements over the last five years, permitted an increase in circuit-breaker trip settings on these transformers in 1956. These new settings enable the transformer to carry up to 20 percent greater overload, without sacrifice of normal service life. More orderly changeout of overloaded transformers is also possible.

Engineering improvements other than the concept of functional life testing are also involved in this change, including use of inhibited oil, more positive sealing of the transformer, as well as improved insulation and design.

Higher breaker trip settings are now being used on single-phase CSP transformers from 3 through 167 kva, and on three-phase units from 9 through 150 kva. Conventional transformers have the same core and coil construction, so that they also reflect this increased capability.

Dry Type Get Smaller, Quieter—The use of higher temperature insulation on dry-type distribution transformers has enabled some notable reductions in size and weight. Class H (group 3) insulation, i.e., inor-

Distribution transformers roll off a production line.

ganic with silicone varnishes, replaces Class B. This, in turn, permits smaller iron circuits and coils. The result is that volume reductions from 25 to 51 percent are achieved, and weight reductions from 16 to about 32 percent.

Sound isolating inhibitors, in the form of rubber pads on which core and coils are suspended, reduce vibration transmitted to the case, and bring about a reduction in sound level of about 6 decibels.

These new dry-type transformers cover a range of 45 through 300 kva, three phase, and 25 through 167 kva, single phase. ■

Test Center for Transformers

■ Hand-in-hand with the remarkable growth in power transformer ratings (see page 10), must go parallel advance in tools for design, development, and testing of these giant units. This fact is exemplified by a huge new anechoic vault and a high-voltage test center for power transformers, which were completed in 1956.

These facilities will serve a dual purpose—commercial testing, as well as research and development—although the primary use will be as an aid in design of future transformers.

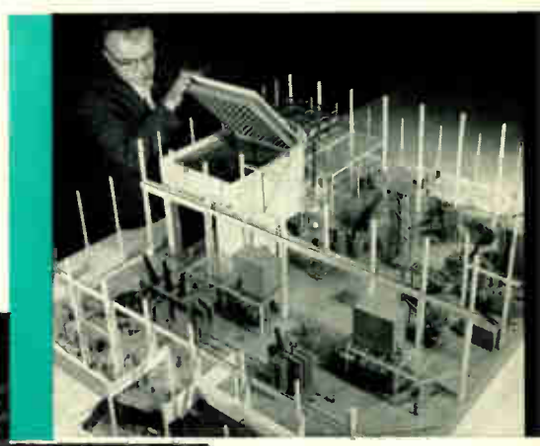
To those familiar with the anechoic, or sound measurement chambers used to test small apparatus, the new chamber is a striking contrast. The vault is some 70 feet long, 56 feet wide, and 57 feet high, and it's large enough to make complete sound measurements on transformers of over 500 000 kva, and weighing over 400 tons. Thus it is large enough to make commercial tests on the largest units forecast for the next ten years.

Many problems will be intensively investigated in this new vault. One will be aimed at discovering methods of reducing vibration and sound in transformers. New core materials and processes will be evaluated to bring about further reduction in noise generated by magnetostriction, i.e., the expansion and contraction of core material as magnetic flux changes. Resonant conditions are another source of sound, and much work will be devoted toward verifying and refining existing methods of calculating and eliminating this resonance. Many other investigations are also planned in this huge new anechoic testing chamber.

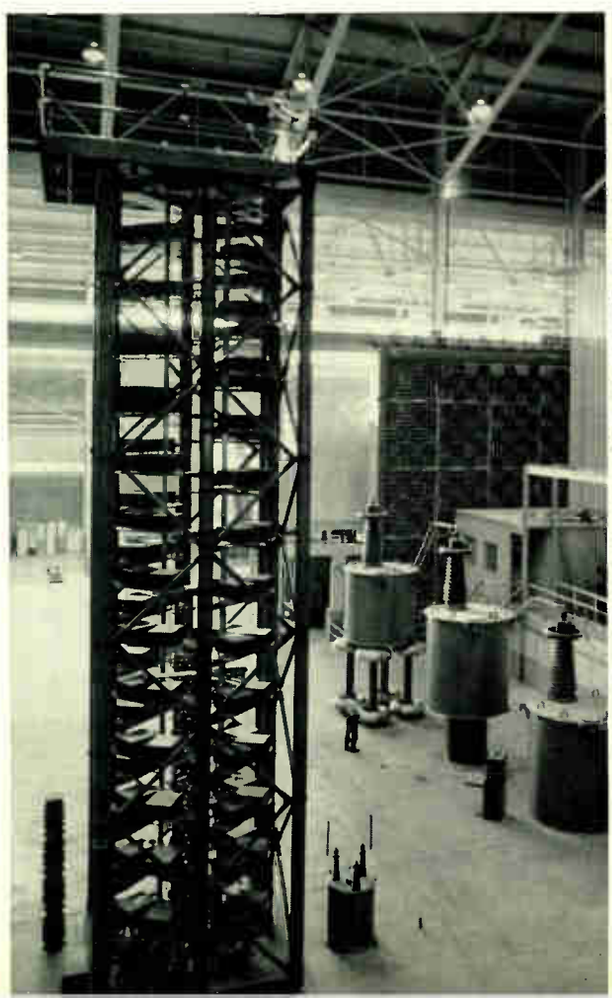
A complete new high-voltage development laboratory is also part of the new facilities. This will be used primarily to test new insulation structures of various materials and configurations. Insulation models, and even full-scale transformer models will be tested to destruction as part of the program to gain more knowledge for design engineers.

Radio-influence testing will play an important part in the development of better insulation structures, thus helping to solve the problem of building transformers of larger rating without a proportionate increase in size. Present power transformers are corona free, and thus radio-interference from this source is non-existent. However, insulation structures that will remain corona-free at higher voltage gradients are needed for transformers of the future.

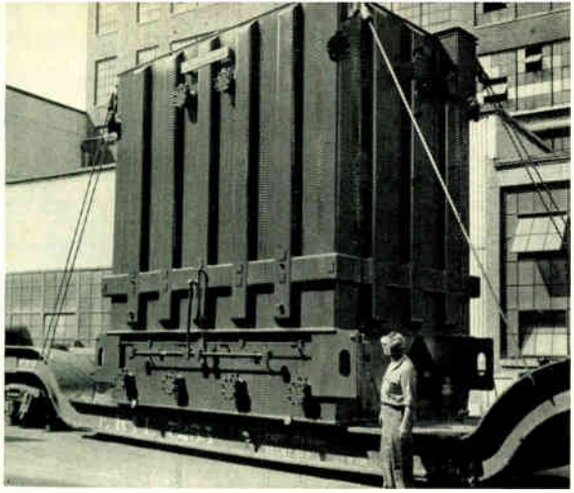
Out of these new facilities, shown in part on these pages, will come the information needed to continue the present rate of growth in kva rating into the future. ■



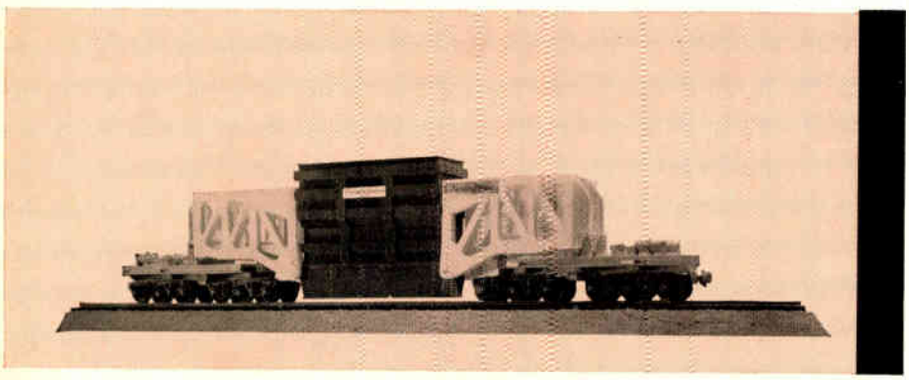
A model of the recently completed anechoic vault and high-voltage test center for transformers.



Two components, shown in the model above, are the surge voltage generator (left) and the anechoic vault.



A 315 000-kva transformer leaving the factory in 1956.



As power transformers grow in rating and physical size, the problem of "getting 'em there" becomes more tricky. The problem is threefold. First, comes the problem of planning a route to the installation site. This route is often a devious one, taking into account gross weight and special clearances such as bridges and tunnels. Second, the transformer must be designed as compactly as good engineering will permit. And third, a car must be found with sufficient load capacity and minimum height from loading platform to rail.

A new railway car, called the "Schnabel", for transporting these giant transformers will go into service in 1957. As shown in the scale model (see above), the transformer will be suspended between the two sections of the car, such that it becomes the center of the car itself. In this way the transformer is transported with a clearance between the bottom of the transformer and the rail of a minimum of six inches.

One of the many special features of the "Schnabel" is that the pivot points of its two halves are offset from the load point. This enables the loaded car, which has an over-all length of about 90 feet, to negotiate the same curves as a standard box car.

Power Transformers—Still Growing!

■ The pace at which large power apparatus continues to grow in kva rating is almost phenomenal. In 1950, on these pages, we reported proudly the installation of a 145 000-kva three-phase transformer. This was truly a giant for its day, although transformer engineers at the same time announced their willingness to tackle a 200 000-kva design. Few engineers could have anticipated the rapid growth in the past six years. In 1956, a 315 000-kva generating-station transformer became the largest capacity of that type installed in the world today. Despite its huge rating this unit was shipped upright and completely assembled, except for oil, cooling equipment, and bushings. Shipping weight of this behemoth was 325 000 pounds, its completely assembled weight 448 000 pounds. A sister unit of the same rating (above, left) was also delivered in 1956.

But the ceiling in rating is apparently nowhere in sight. Several much larger units are already in design or early construction stages. One is a 325 000 kva unit for stepping up generated voltage of 16 kv to 138 kv. Another is a 360 000-kva generating station unit that will step up the generated voltage of 18 kv to 120 kv. This unit—with a shipping weight of 340 000 pounds and a total weight of 458 000 pounds—will also be shipped to the installation site upright and in one piece.

A second 360 000-kva unit for another generating station will step up the generated voltage of 18 kv to a slightly higher voltage—138 kv. This will be slightly heavier—351 000 pounds shipping and 461 500 pounds installed weight—but will also be shipped upright and in one piece.

But the largest transformer now in design stages is a 380 000-kva unit, designed to step up a generated voltage of 18 kv to 69 kv. Again the unit, despite its tremendous size, will be shipped upright and in one piece.

Obviously transformers of over 300 000 kva are becoming more commonplace. These, of course, are generating station transformers—an even larger 400 000-kva autotransformer has been in service for about a year. Thus in the short space of six years conventional units have almost *tripled* in kva rating. ■

Switchgear

Switchgear Developments

■ Oil has long been the standard interrupting medium for high-voltage, high-power outdoor circuit breakers in this country. With the ready availability of oil in the United States, the oil breaker has been perfected to be the most reliable breaker of its type. Furthermore, the dead-tank design with bushings to accommodate current transformers have operating advantages that oil has previously enjoyed over high-voltage air circuit breakers—until this year, that is, when a new compressed-air breaker design was completed for a new 138-kv, 10-million kva compressed-air breaker. It departs completely from previous compressed-air breaker designs using porcelain under air pressure for structural members and insulation to ground, which generally required separate, costly current transformers.

The new compressed-air breaker, with tanks and bushings, externally resembles an oil circuit breaker. Each phase of the interrupter is contained in a separate steel tank in air at 250 psi. The operating and linkage mechanism is much like that of the oil breaker; when the breaker is tripped, a crossarm inside the tank moves downward, driven by an accelerating spring, and pilots a trigger valve on each of two interrupters. This sets up a pressure unbalance across a main actuating piston, and the piston drops, opening the blast valve and drawing an arc in an orifice. The current is then shunted into a parallel resistor. The arc is then interrupted by the blast of air from the tank through the orifice, and out through the

hollow conductor of the condenser bushings. The crossarm stays open whether or not there is air in the tank, thereby providing positive and permanent voltage isolation.

Advances in the efficiency of the interrupting device, which fundamentally is an orifice through which compressed air is exhausted as the breaker contacts are separated, have been made. Previously, air circuit breakers were limited in the amount of current that they could interrupt for a given voltage stress across the orifice. Changes in the geometrical configuration of the orifice and application of new materials in this type of interrupter have made the higher rating possible.

The first units have been installed on the Consolidated Edison System of New York. The new breaker will find its greatest application advantages in such large metropolitan areas, where oil storage, handling, purification, and the fire hazard accompanying the presence of oil are objectionable.

Reduced maintenance time and expense is a further advantage of air over oil. Since contacts are immersed in compressed air rather than oil, they are more readily accessible for inspection and maintenance. Consequently, breakers are out of service for shorter periods of time during routine maintenance inspections and adjustments.

The Consolidated Edison installation is unusual from the standpoint of air supply, in that system pressures at 1000 psig have not ordinarily been used. This higher storage pressure provides greater capacity and drier air for breaker operation. This pressure is reduced to 250 psig for breaker operation.

The rating, 138 kv and 10-million kva interrupting capacity, was chosen to meet the major number of potential applications. This breaker rating has been and is expected to continue to be very popular. ■

Developments with SF_6

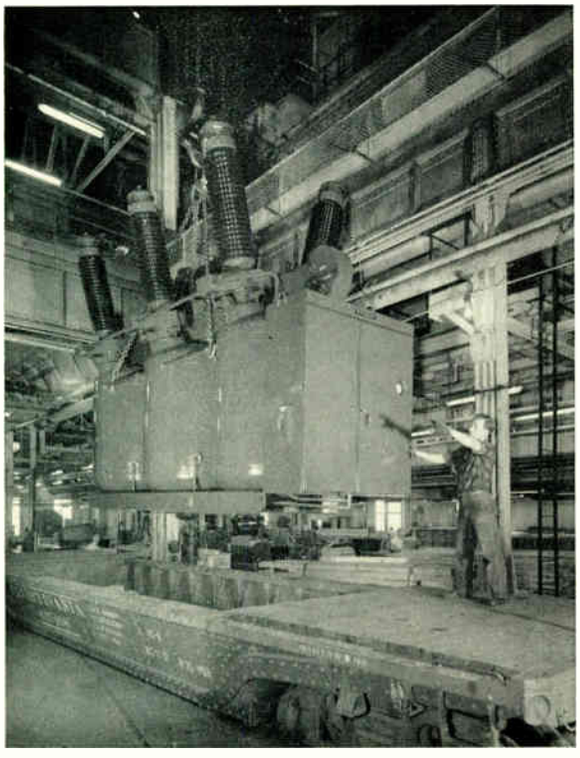
■ Sulphur hexafluoride gas has many desirable qualities for arc-interrupting devices. SF_6 has already served as the interrupting medium for a load-break interrupting switch (type VLB). It is now getting a tougher assignment, as a one-million-kva circuit breaker. This is the first power device using sulphur hexafluoride, and is now installed on the Gulf Power Company system.

The characteristics of SF_6 as an interrupting medium have resulted in several design advantages. Since the gas can be used at a relatively low pressure of about two atmospheres, and only a small amount is needed because of its excellent insulation properties, gas pressure and volume can be kept to a minimum, thereby making a porcelain device desirable.

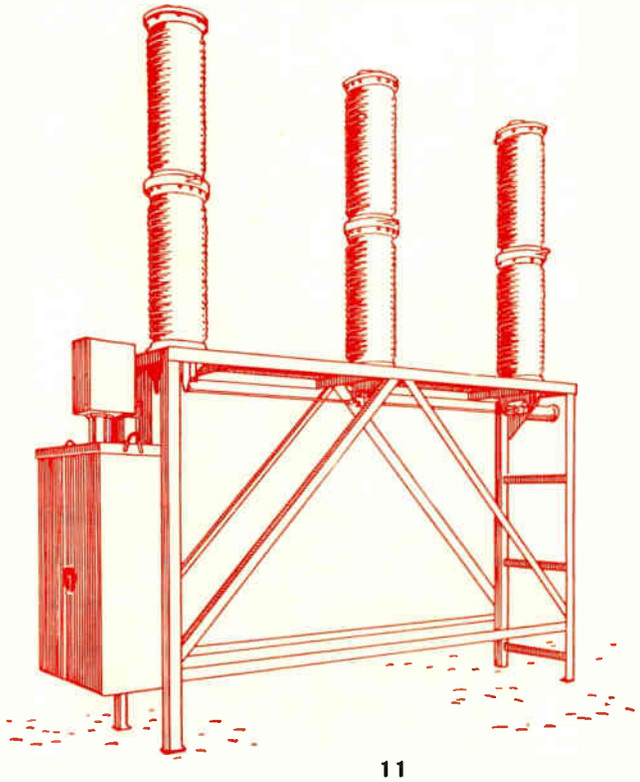
Since the sulphur hexafluoride breaker is restrike free, the breaker is particularly suited for capacitor switching, either for single banks or bank against bank. The first installation on the Gulf Power system will be at 115 kv.

Automatic 5-Cycle Grounding Switch—The previous protective device protected the system by opening the circuit when a short circuit was detected—grounding switches use just the opposite method to provide protection. Upon discovering a small fault, the switch closes and provides a solid ground fault.

How does this protect? Automatic grounding switches used on utility systems are generally applied to protect transformers that serve customers at remote locations. A local "high-side" breaker may not be justified simply to protect the transformer in the event of a transformer internal fault. The grounding switch provides this protection by amplifying the small internal fault to such a current that remote breakers supplying the transformer are tripped.



Ten-million kva air circuit breaker is loaded for shipment.



A one-million kva circuit breaker uses sulphur hexafluoride as the interrupting medium.

Therefore, although the transformer fault current is not large enough to operate remote relays, local relays can easily detect the trouble and operate the grounding switch. The remote transformer is thereby removed from service before it is extensively damaged.

Automatic grounding switches that have been in use up to this time have been of the hinged-blade type, requiring 15 to 30 cycles time to close. While this basic approach to high-speed ground switches has generally been acceptable, the advent of faster operating time for breakers and relays has made the conventional grounding switch with 15- to 30-cycle operating time obsolete for coordination with faster-acting breakers and relays.

A completely new approach to the grounding switch, using a reciprocating rod in place of the pivoted blade, and encasing this rod in a porcelain weather casing filled with sulphur hexafluoride, has resulted in a gound switch with 5-cycle operation. In addition to faster operating time, the new switch will close 20 000 amperes. Furthermore, the unit is not susceptible to icing. The sulphur hexafluoride gas also minimizes contact burning, and allows the stationary and moving contact to be positioned much closer than possible in air. Hence, increased speed is obtained by closer contact spacing and a faster type of operating mechanism. The first application of the switch has been made on the Pennsylvania Power and Light system, on a 196-kv circuit, to close 20 000 amperes. ■

Greater Capacity For Capacitors

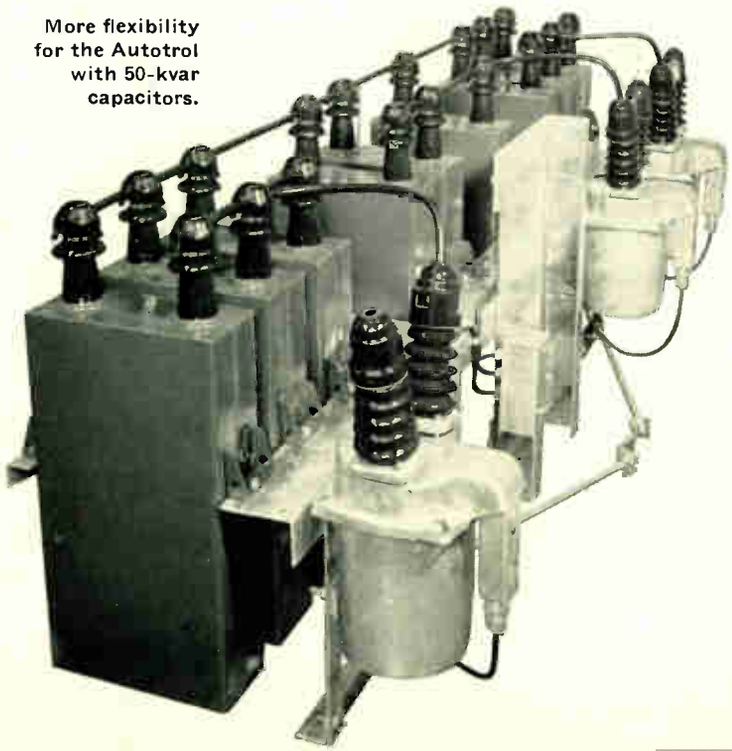
■ Advances in materials and processing technique have pushed up the maximum economic size for capacitor units used for power-factor correction on distribution and subtransmission lines. The new line of 50-kva capacitor units is double the capacity of the previous high, and comes in voltage ratings from 2400 to 7960 volts.

Although for some smaller bank sizes, a 25-kva unit is still necessary, the larger unit has several advantages for large banks. More kva can be put in a more compact, stack-type assembly. Although the 50-kva unit is taller than the 25-kva unit, the volume is not doubled, so that the kva is doubled without doubling the cost of steel work and individual fuses.

The features of the 25-kva unit have been retained; the case is zinc sprayed, and the bushings solder sealed to the case. The same degree of reliability is maintained by using more insulation.

The 50-kvar capacitor has given the Autotrol greater flexibility. The Autotrol—the pole mounted, factory-built capacitor assembly complete with oil switches—was previously limited to a maximum of 300 kvar. It now can be made in sizes from 75 to 600 kvar, for voltages 2400 to 13 800 volts. At the same time, the larger unit makes possible a 23.5-percent weight reduction per kvar.

Coupling Capacitor—A 115-kv coupling capacitor unit has been added to the previous 46- and 69-kv line. Biggest advantage of the new unit is lower stacking height for voltages of 115 kv and above. The previous 115-kv design required 46- and 69-kv units stacked in series, resulting in a height of 86 inches. The new single 115-kv rating unit is about one foot shorter. Consequently, in the higher voltage applications, both the number of individual units required, and the total height of the combination can be reduced. ■



More flexibility for the Autotrol with 50-kvar capacitors.

Loadbreak Cutout

■ Heavier loads and higher associated distribution circuit voltages have created a switching problem for distribution cutouts. Formerly, distribution circuits could be disconnected merely by yanking open the cutout; now opening the cutout is followed by persistent arcing between the top contacts. Design engineers have come up with a simple solution—why not use the existing interrupter in the fuse cutout to extinguish these higher, difficult-to-switch load currents? The resulting new loadbreak cutout is designed to interrupt load current as well as fault current. Here's how it works.

When interrupting fault current, the cutout performs in the conventional manner; the fuse link blows and the fuse holder drops down to visibly indicate the operation. To interrupt load current, the fuse link is broken mechanically by a lever-operated toggle mechanism located at the lower end of the fuse holder. A unique roller device coupled to the toggle linkage applies uniform tension to the lower end of the link, insuring link breakage at the fusible element inside the fuse tube. The resulting arc is interrupted just as if the cutout were interrupting a fault current.

The loadbreak fuse holder can be fitted to existing fuse cutout (Type DX) installations. It is easy to install, and complete hookstick operation makes loadbreaking and re-fusing simple.

The cutout is designed for distribution circuit voltages of 5.2, 7.8, and 15 kv. The loadbreak mechanism will break fuse links rated from 5 through 100 amperes, the continuous current rating of the cutout. Maximum fault interruption is 5000 amperes.

Free of complicated parts, the toggle mechanism's

current-carrying member is a silver-plated non-ferrous casting. Heavy galvanized sleet shields provide weather protection for the contacts. The shields are attached to the porcelain by insulated clamping bands that provide bird-proofing. ■

Arcs Go Round and Round

■ A small doughnut-shaped ceramic magnet is making life miserable for arcs in lightning arresters. The magnet placed mechanically "in series" with the gap surface provides a constant magnetic field in the gap. When the arc is drawn, it is at right angles to the magnetic field, and therefore spins like the armature winding of an electric motor. Previously, the arc tended to stay in one place. With discharges of relatively long duration, such as switching surges, there could be pitting at those spots on the electrode surfaces. This could eventually change the arrester sparkover. When the arc spins and moves, it cannot build up on one spot, so that gap life is lengthened. Likewise, the ability of the gap to interrupt power-follow current is improved. Since the arc must spin, electrode spacing has been simplified by placing a small pimple on one surface; only this pimple spacing is critical. Once the arc is drawn, the magnetic field drags it off the pimple, and around the gap, helping interruption.

The ceramic magnet is made of barium ferrite, which electrically is an insulator. However, its magnetic life is almost infinite. The magnet is also shielded so that the discharge currents go around the outside of the magnet and therefore do not cause demagnetization. Currents of 100 000 amperes have been measured in the gaps with no ill effects to the magnets. The reliability of the new device lies in its utter simplicity. The new magnetic design is being used in all station and line type arresters.

A new arrester design has also been added to the existing line of station arresters. Several columns of elements are arranged physically in parallel and electrically in series in the same porcelain housing. This results in a more compact design, which is completely self-supporting, with no bracing required for even the highest ratings. Lower overhead clearances and less steelwork for substations are additional benefits.

Like the standard station arrester, the new design has the pressure-relief feature. The units are made in ratings of 60, 48, 36, and 18 kv. Any desired voltage rating is made from multiples or combinations of these various basic ratings. ■

Metal-clad Switchgear

■ The use of metal-clad switchgear, both indoor and outdoor, is expanding each year. These self-contained units, with magnetic circuit breakers, are ideally suited for unit substations, powerhouse auxiliary switchgear, and industrial plants. The most attractive advantage of the metal-clad unit is that it is completely self-contained. No external supplies are required, and no extra investment for housing

Even the simple disconnect switch can be redesigned to advantage. This redesign of the existing line of RL switches is a side-break disconnect switch, with a new concept for contact surface—a sponge-copper contact, which is more versatile than the previous design.

While they were at it, engineers also decided to redesign the motor mechanism, which drives gang-operated disconnect switches. The redesign features dust-tight housings, crank-handle operation in event that manual operation is required, quiet operation, and a more positive operation of auxiliary switches and position indication. The auxiliary switch, which is driven in synchronism with the disconnect switch being operated, has completely adjustable make-and-break circuits. This permits coordination of the disconnect switch with other electrical equipment by supplying a "make" or "break" circuit for any phase of the disconnect operation. Furthermore, adjustment of the auxiliary switch can be readily made in the field. In former designs, if a user wanted to energize an indicating circuit at the very instant that the arcing horns separated on the disconnect, for example, the auxiliary switch mechanism had to be designed at the factory. Now this is a simple field adjustment.

Ceramic magnet shows in this cutaway of arrester spark gap.

space is needed. The present line of magnetic breakers has been extended to 750 mva, and continuous-current ratings in some units up to 3000 amperes in 5-kv equipment. Interrupting time has been shortened to five cycles on the standard breaker.

The first magnetic two-cycle breaker, dubbed the 50-DHHS, has now been developed for distribution circuits, where a fast interrupting time is required to reduce wire falls caused by arc burns. During storms, arc burning due to falling branches can be kept to a minimum, and hence the chances of the wire being weakened or burned through are reduced. Another advantage of two-cycle interruption is improved coordination with distribution system fuses.

Instead of the usual *mva* rating, the two-cycle breaker will have a *current* interrupting rating of 30 000 amperes at 4.16 kv, with a momentary current rating of 40 000 amperes. Continuous-current rating is 600 amperes. The contact parting time is ¾ cycle from the energizing of the trip coil to parting of the arcing contacts; the arc is interrupted within two cycles from the time of energizing the trip coil. The unit is mechanically interchangeable with present 150- and 250-mva magnetic breakers. Now the fastest power-circuit breaker available, the new units are expected to be used widely as distribution feeder breakers in 4.16 distribution circuits.

For The Powerhouse—Another 4160-volt magnetic air breaker is being designed with current ratings of 1200 to 3000 amperes. Previous continuous ratings in the 5-kv line were 1200 and 2000 amperes. The new unit has a momentary current rating of 80 000 amperes, and an interrupting rating of 350 mva. The unit was designed primarily for use in power-house auxiliary systems, or wherever this high continuous carrying or interrupting capacity is required.

Metropolitan Substations—For distribution substations in metropolitan districts, where large transformers are required, a new 13.8-kv magnetic air circuit breaker has an interrupting capacity of 750 mva. This extension of the previous high of 500 mva will handle the higher fault currents possible with larger transformers.

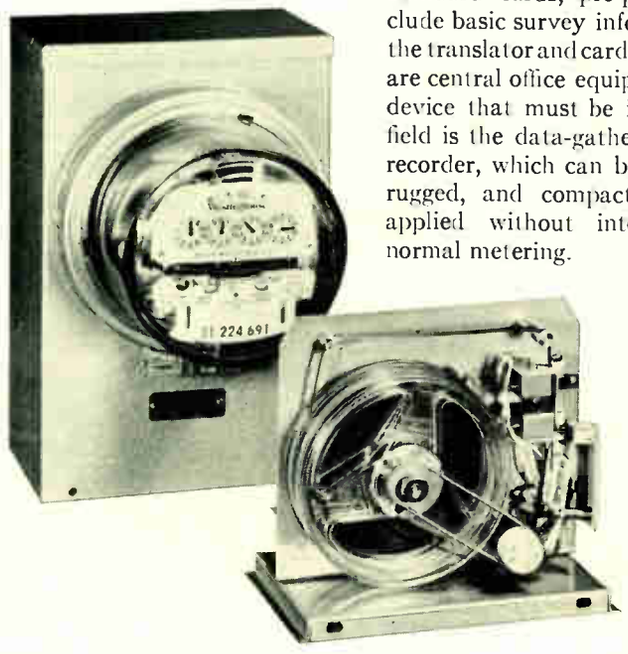
Although the new metal-clad unit has 50 percent greater interrupting capacity than the next lower rating of its type, it has the same height and width, and is only 6 inches deeper. Since the 500-mva and 750-mva breaker units are similar, it is possible by slight modification of the 500-mva breaker barrier to adapt it to fit a 750-mva housing (1200 or 2000 amperes). Hence, the user can build a substation today, and use 500-mva units initially; as the station capacity expands, the breakers can be then converted to 750-mva units. ■

Measurements, Instruments, and Relays

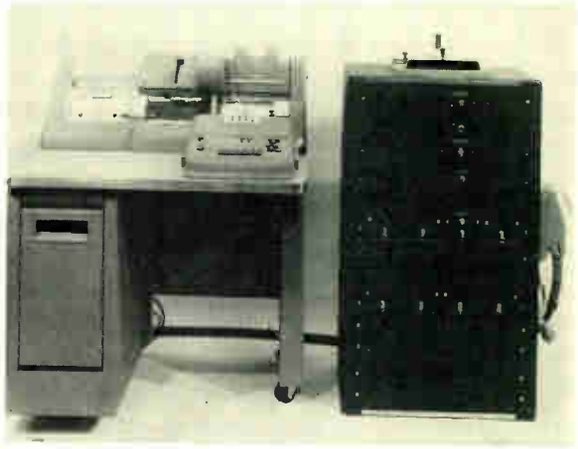
Load-Surveys—Automatically

■ Current forecasts indicate average residential electrical loads are to double within the next ten years. This means electric utilities will need more timely and accurate data to foresee the effects on system load curves. A new load-survey recorder gathers and processes this data automatically.

The new survey system consists of a compact recorder that transcribes load and time quantities on magnetic tape; a translator that interprets these impulses as demand values; and a summary card-punching machine, which transcribes values to standard cards, pre-punched to include basic survey information. Since the translator and card-punch machine are central office equipment, the only device that must be installed in the field is the data-gathering device, or recorder, which can be made simple, rugged, and compact, and can be applied without interference with normal metering.



At the customer's meter, the recorder keeps track of time and load via impulses on standard 600-foot lengths of dual-track magnetic tape. At a recording speed of 9.4 inches per hour, standard tape lengths permit a 32-day survey without attention to the device. Outages are indicated by a clock.



The recorder will be available in three different forms. One is a complete socket-type unit incorporating a 15- or 30-ampere DS meter; a second is a socket-type unit with provision for retaining the customer's original meter in service; the third is a separately housed recorder unit for connection by cable to a 3-wire, 120/240-volt A-base meters.

After the survey has been run, the tape is brought to a central location for playback on the translator unit, which converts time and load impulses into demand values. A 32-day tape can be processed in either 35 or 18 minutes, depending upon whether 15- or 30-minute demand intervals are required.

Plug-in connectors carry information directly from the translator to an IBM 526 card-punch machine. Here survey data is punched into cards that have been pre-punched with other pertinent survey information, such as customer identification, date, etc.

Each punched card accommodates 16 demand intervals, which means that one card is adequate for a four-hour survey when the demand interval is 15 minutes. At this same interval, 2880 individual demand readings taken during a one-month survey can be contained in 180 cards.

Through the new system, modern information-handling methods thus can take over the job of load surveying, without the need for human interpretation and its risk of errors. ■

Instruments Get New Look, New Designs

■ DEVICES FOR MEASUREMENT and recording of electrical quantities came in for a generous share of attention by design engineers last year. Several of the results were notable.

Brand new mechanisms were developed for instruments that measure a-c volts and amperes (KA-24) and those that measure power factor and synchronism (KI-24). The voltage and current mechanism utilizes the principle of repulsion and attraction forces acting on a moving vane; in addition to increased efficiency, the new instruments have more consistent and uniform scale distribution, and improved accuracy at high frequency. Lighter and lower inertia elements result in faster response and less pivot friction.

Better readability at greater distances was the goal in a new group of circular scale switchboard instruments. These have a big eight-inch diameter dial, thus enabling the instrument to be located higher on the switchboard and further from the control center. ■

News About Meters

■ Although their basic principles have remained the same, watthour meters have come a long way in versatility and in the information they can provide. Two examples of recently developed meters are indications.

Watthour Thermal-Demand Meter—A new meter design indicates not only the kilowatthours used, but also the maximum kva demand, based on an assumed voltage, utilized by a customer during the billing period. Kilowatthours are recorded by a single-phase watthour meter element. The kva demand is indicated by a thermal unit that operates on the logarithmic principle.

The thermal unit consists of two bi-metal springs, wound in opposite direction to compensate for ambient temperature changes, and mounted on a common shaft. One bi-metal spring is enclosed by a heater which is fed from the secondaries of two current transformers. The primaries of these current transformers are the series windings of the watthour meter. Consequently, the amount of heat applied to the bi-metal spring is proportional to the current drawn by the load. When heated the bi-metal spring rotates and indicates on a scale the maximum demand during the period. By assuming a constant line voltage the scale can be marked in kva and thus give the maximum kva demand during the billing period. The thermal unit functions independently of the watthour element and is designed to reach 90 percent of its final value for a constant load in 15 minutes.

The type QDS meter is rated at 240 volts, 15 amperes, 60 cycles, three wire, single phase, with a maximum kva demand of 24. All components of the meter are designed to have an insulation level of 10 000 volts withstand-impulse voltage.

Convertible Watthour Meter—Increased use of electricity in the home has resulted in an almost universal use of 120/240-volt, three-wire distribution to new houses, compared to the two-wire service previously found in homes. Thus the problem exists for utilities of having two different types of meters in service. A new meter can be used on either two- or three-wire service. As built, the unit is connected for use on the older two-wire system—but can be changed for three-wire application when required.

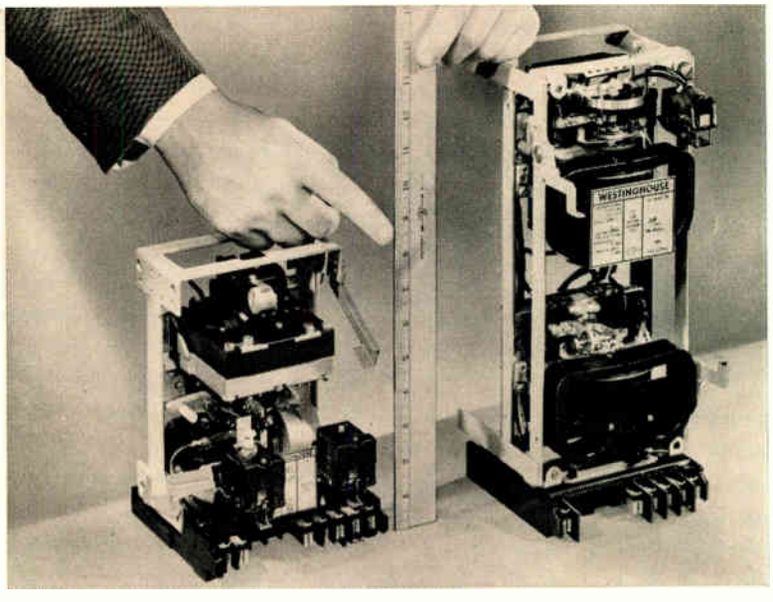
For two-wire use, only one of two current coils is used and the two sections of the potential coil are connected in parallel. A change to three-wire use is brought about simply by utilizing both current coils, and connecting the two potential coils in series for 240-volt use. ■

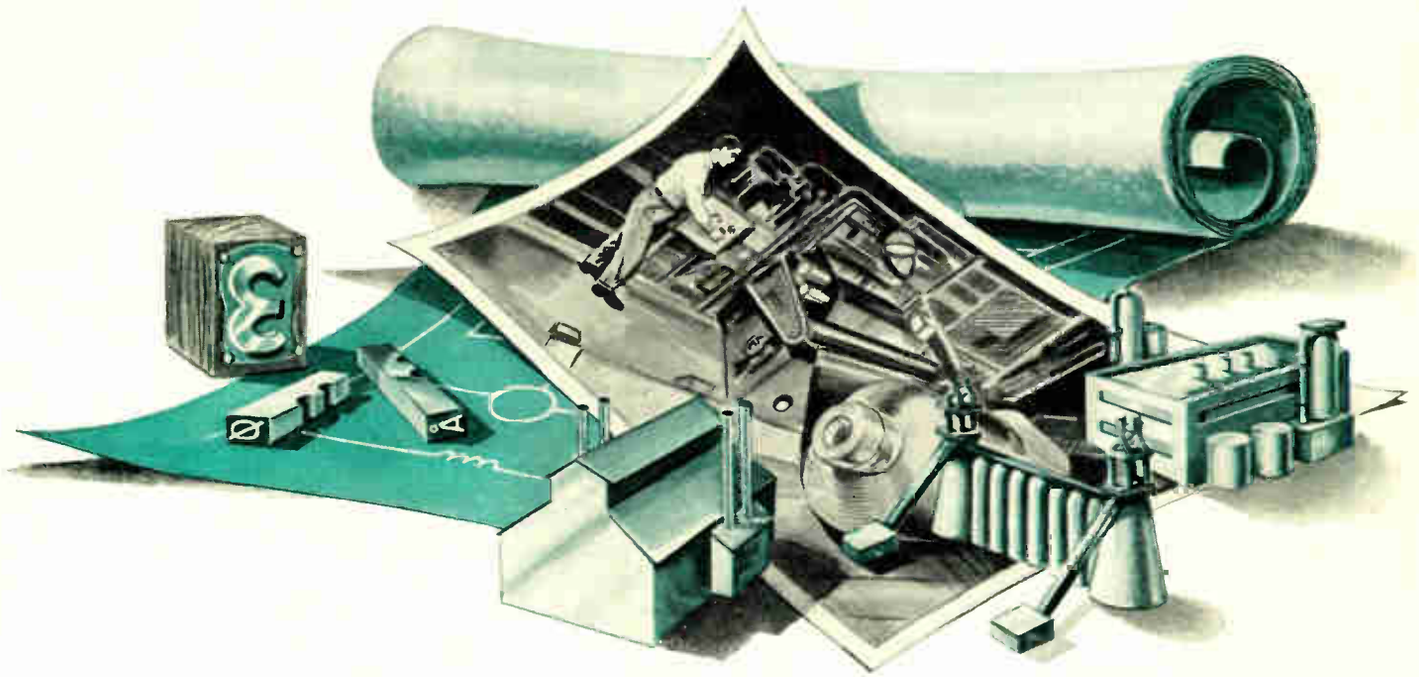
Less panel board "real estate" is required for new relay designs with their Flexitest cases. One-third smaller than previous designs, eight relays can be put in the same space formerly needed for only five.

While making them smaller, design engineers also provided simple, accessible construction to assure reliable operation with a minimum of maintenance. Case size has been reduced vertically by one third, while width remains the same as previous designs. The new case provides more efficient utilization of space within the case, thus permitting the inclusion of external auxiliaries (such as resistors) that previously required additional back-of-panel mounting and wiring. The Flexitest cases can be used for both projection and semi-flush mounting, which makes possible smaller relay inventories and simplifies ordering procedures.

The new designs are available in the complete line of the types CO overcurrent, CR directional overcurrent, and CV voltage relays. In addition, all relays previously mounted in Flexitest cases are now available in the new improved Flexitest case with the modern appearance.

A low-burden electromagnet is used in the relay. Lower burden permits greater loading of existing current transformers. Thermal capacity has been increased, making relay operation more accurate there is less temperature error.





Applications of Power

Industrial Drives and Control

Card Programming for Steel Mills

▪ Card-programmed control has numerous possibilities in industry. Many different applications have been forecast or discussed; some have assumed more concrete form. For example, at Jones & Laughlin's Aliquippa Works, a card-programmed control for a reversing roughing mill is scheduled to be installed in 1957.

To initiate a rolling schedule, the operator places a stack of IBM cards in a card reader, in the order in which they are to be used. When the schedule advance button is pressed, the first card passes through the machine in less than a second and all information for that particular schedule is stored in transistor type memory devices.

If several slabs are to be rolled for a given schedule, this information is used over and over again to roll any number of slabs. Such cards will be available for nearly every slab and strip size and for each grade of steel.

After the information for a particular schedule has been stored in the transistor elements, the mill is ready for the slab.

As the slab approaches the mill, the operator pushes a pass-advance button, which initiates the sequence of operations, and the control takes over, directing the entire mill.

The single card includes all information required for a given schedule, and controls: (1) mill screwdown opening, (2) edger adjustment opening, (3) mill speed, and (4) edger speed, which is matched to mill speed but is usually slower.

To make the mill operation completely automatic, a detector sensitive to strip radiation initiates a slowdown when the tail end of the strip approaches the mill. A strain gauge detects the instant that the strip leaves the mill for fast repositioning of the rolls and re-entering for the next pass. ▪

Steel Mill Crane Goes A-C

▪ A trend in industry is to do away with d-c buses as a power supply. In many mills, the necessary length of the bus would make the power loss too high. Where d-c drives are needed, they are more and more becoming individually powered by their own rotating conversion equipment. On steel-mill cranes, this means extra equipment, since most cranes are powered by constant-potential d-c drives.

A change in this situation came about last year (1956) when the first major a-c crane installation was made in a steel mill. This utilizes Load-O-Matic controllers to control two large gantry cranes over a slag pit. One crane handles a clam-shell bucket, scraping slag at one end of the pit; the other hooks to a skull cracker, a magnet, or a slag pot as necessary. Use of the Load-O-Matic means a minimum of control components, and eliminates reversing contactors and rotating conversion equipment. Also the controller is front wired (with color coding), in channels, which saves space and time in the installation.

On the same cranes, braking the rail-clamp drive is accomplished by a capacitor-type of braking. Basically this consists of an a-c motor with capacitors across its terminals. The rail-clamp itself is a scissor-like device with a weight or spring so arranged that it tends to close the clamp on the rail unless held open. The a-c motor opens the clamp, and the weight is held in the open position by a shoe brake. Freed by the shoe brake, the weight or spring applies braking force to the rail through the scissor-like clamp. To accomplish smooth stopping however, the weight must be lowered slowly. With capacitor-type braking the a-c machine operates as a generator, with excitation supplied by the capacitors, thus applying dynamic braking on power failure or stop. The capacitor braking provides the necessary time delay to avoid setting the clamps too quickly. ▪

Higher Speeds, Faster Response for Arc Furnaces

■ Electrodes for the large electric arc furnaces being built today weigh from 15 to 20 tons apiece, and travel from 6 to 12 feet per minute. Yet should the electrode hit a piece of scrap in its descent, or for any other reason have to stop suddenly, it must do so immediately, with just as little delay as possible. A new Magamp regulator for arc furnaces will accomplish just that.

As arc furnaces have increased in size and capacity, a concurrent requirement has been faster response and increased sensitivity from the regulators, and faster speeds for electrodes. The familiar rotating regulator has about reached its limit as far as response is concerned. The newly developed Magamp regulator actually is capable of driving the furnace electrodes at speeds and responses up to the limit that the drive motor can stand. Commutating ability of the motor is the ceiling that limits the electrode speed and response that can be furnished by the control. Thus to make sure that the drive motor does not unduly limit the new control, low-inertia steel-mill motors, specifically designed to commutate heavy armature currents, are used.

The Magamp regulator for each electrode uses a reversing magnetic amplifier to control a motor-generator set. Signals of arc voltage and arc current are compared by the regulator. Magnitude and direction of the output depends on which of the signals is the stronger, and on the ratio of the signal strengths. Generally speaking, the voltage provides the "lower" signal, current provides the "raise" signal. A motor-generator set in turn powers the electrode motor, following the directions given by the regulator. Auxiliary equipment limits the electrode speed, motor armature current, maximum arc current, and other factors. ■

More Mills Go Magamp

■ Although magnetic amplifiers are now an established and well-accepted member of the regulator family, they still continue to find new and interesting applications. And although their primary advantage is the fact that they are completely static devices, other advantages also accrue, as indicated by some recent applications.

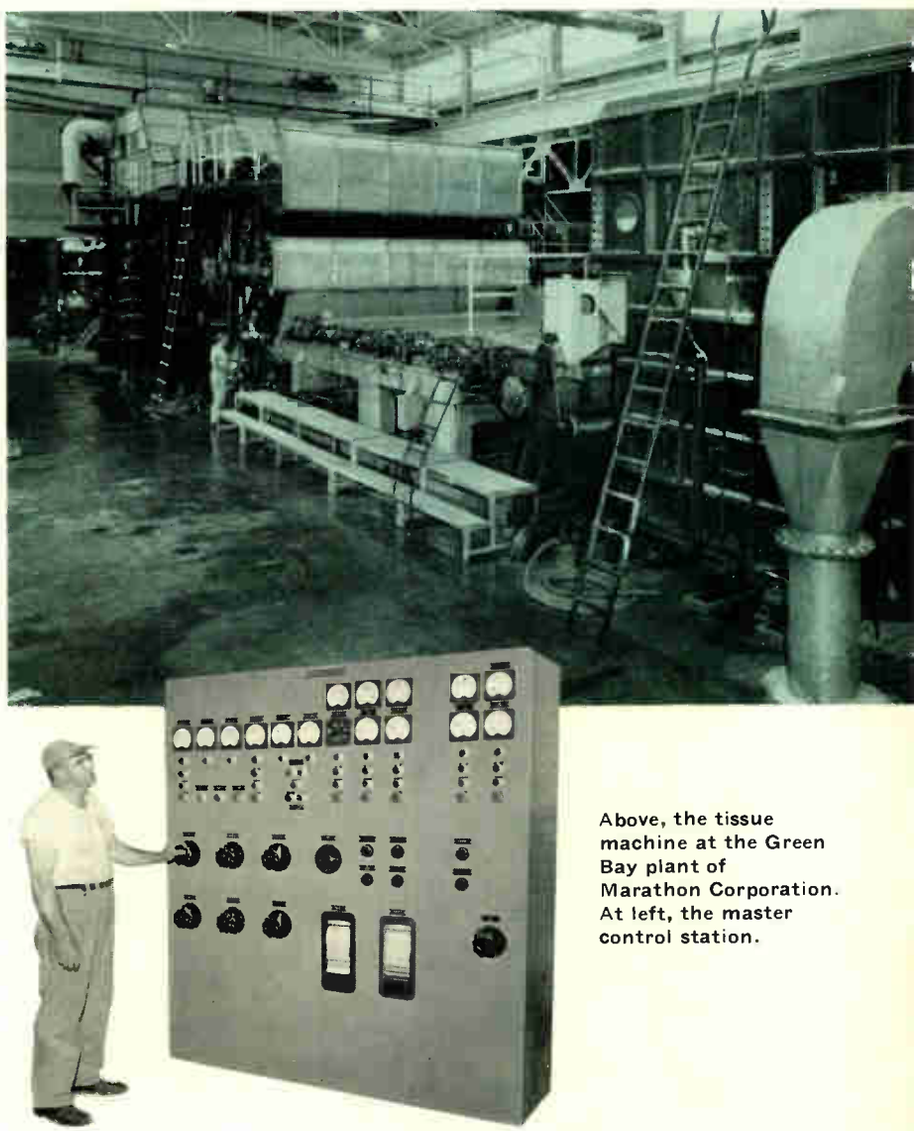
Automatic Control of Strip Thickness—In industry, time is money. Nowhere is this more true than in high-production processing, such as found in the steel industry. This maxim even extends down to the response time of automatic controls. For example, in rolling steel strip to a specified thickness, the faster the mill gets "on-gauge" the better the yield from the tandem-mill process. In the past, the adjustment of stands to obtain correct strip thickness has been accomplished manually by mill operators; now, thanks to a new automatic gauge-control system, it can be done faster and automatically.

The new system utilizes a thickness gauge between the first and second stands as a thickness-error indicating device. This error signal is fed to the first-stand screwdown control to reposition the screws and eliminate the error. This provides a coarse control of strip thickness. An additional thickness gauge is located between the last stand and the reel, and provides an error signal for operating the vernier-gauge control regulator. This regulator controls gauge by adjusting the tensions between the stands of the mill to assure the exit thickness of the strip on gauge.

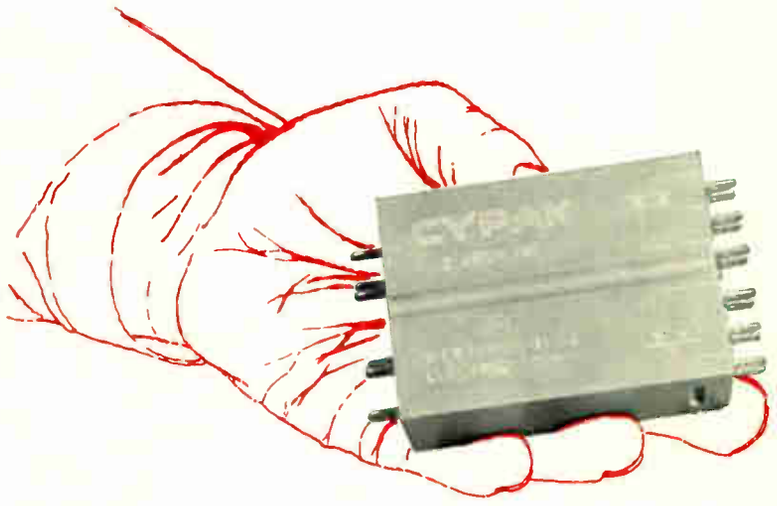
Fast response is obtained by a combination of 400-cycle Magamp regulators designed to operate in conjunction with the main-drive 400-cycle Magamp regulators of the cold-reduction tandem mill.

Tissue-Machine Sectional Drive—On many types of paper machines the position regulator has no peer. Not so with tissue machines. Here there is frequently a wide speed range between individual sections—and in such a case speed regulators are a necessity. A new system for tissue machines is a Magamp regulated sectional drive using pilot-generator feedback for speed regulation. This system controls a 192-inch-wide tissue machine over a speed range of 650 to 2500 fpm.

An exciter is regulated to provide a reference for the whole drive. Couch, press sections and Yankee dryer all receive power from the same generator.



Above, the tissue machine at the Green Bay plant of Marathon Corporation. At left, the master control station.



The "brain cells" of Cypak systems are now encapsulated in solid polyester blocks. Plug-in power connections are at one end, signal input and output terminals at the other.

The two calenders and the reel obtain their speed reference from a motor-operated rheostat on the wet-end generator. Each of the calenders and the reel has its own two-stage Magamp regulator and is separately adjustable as to speed.

The control is so designed that should the pilot generator fail, the entire drive can be shifted from speed regulation to voltage regulation, simply by throwing switches provided for this purpose. In this event the motor-operated rheostat on the wet-end drive still acts as a reference for the calenders and reel. The first application of this system is at the Green Bay plant of Marathon Corporation (see photo, p. 17). This type of drive is suitable for any tissue machine, regardless of size.

Kraft Mill Kept in Step—Keeping 12 different sections of a paper machine in near perfect step is a rough job, especially over a wide speed range. A new 400-cycle Magamp control system does just that—and with the greatest of ease—on a 158-inch-wide Kraft paper-making machine. This is the first such system for a multiple-generator sectional electric paper-machine drive.

Each of the 12 sections is regulated by a position-type paper-machine speed-matching device supplying electrical signals to the 400-cycle magnetic-amplifier regulator. The new system performs equally well over a wide range of weight and quality of Kraft paper, and over a speed range of 120 to 1200 fpm. ■

Another Cypak Machine-Tool Control

■ The machine-tool industry is a familiar habitat for Cypak systems. A control system has been installed on a 6-station milling and drilling machine built by the Michigan Drill Head Company for use in an automotive plant. A cast-iron cylinder-head manifold is completely machined from the rough casting to a finished part with a total of 31 operations being performed on each work piece. Machining operations include milling, drilling, reaming, chamfering, spot-facing, and tapping. ■

Plant Distribution and Control Devices

AB Breakers Add a Fuse

■ The high concentration of power on low-voltage plant-distribution systems is resulting in higher and more severe currents under short-circuit conditions. Short-circuit currents of 100 000 amperes and higher are now common on such systems. The interrupting ratings of the molded-case AB circuit breakers commonly used for this service are not sufficient to permit interruption of such large currents, although their current-carrying capacity and low overload protection characteristics are adequate for normal circuit conditions.

The solution devised by breaker engineers is to place a high-interrupting-capacity current-limiting fuse in series with the breaker. Limiter and breaker are incorporated in one case. The current-limiter design was selected so that on low currents up to about the interrupting capacity of the circuit breaker, the breaker interrupts and clears the circuit before the limiter blows. Above this point, the current limiter takes over the interrupting chores, acting faster

than the breaker and clearing the existing fault through interruption and current limiting. Thus the breaker is not damaged.

Through this combination, called the Tri-Pac breaker, higher interrupting capacity has been combined with all the features of molded-case breakers, thus eliminating the need for a larger and more expensive device. The range of current ratings for this new device is from 15 amperes to 800 amperes at 600 volts a-c or 250 volts d-c. ■

Two-In-One Bus Duct

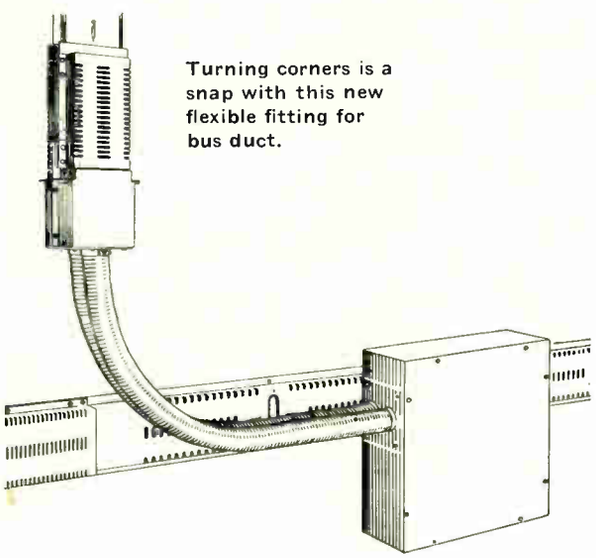
■ Bus duct for distributing power in industrial plants is a relatively new innovation, having first come into prominence during World War II. Since that time, two separate types have been developed, one for feeder use, specifically designed to have low voltage drop for most economical use on long feeder runs, the other with plug-in openings for use in the areas where the power is to be used.

The newest design combines the best features of both. It has low voltage drop, plug-in openings, and many safety features. Lower voltage drop is accomplished in much the same way as in the feeder-type duct—with multiple current-carrying insulated bars closely spaced. Plug-in openings are provided to take off power from these bars through outlet covers with safety interlocks.

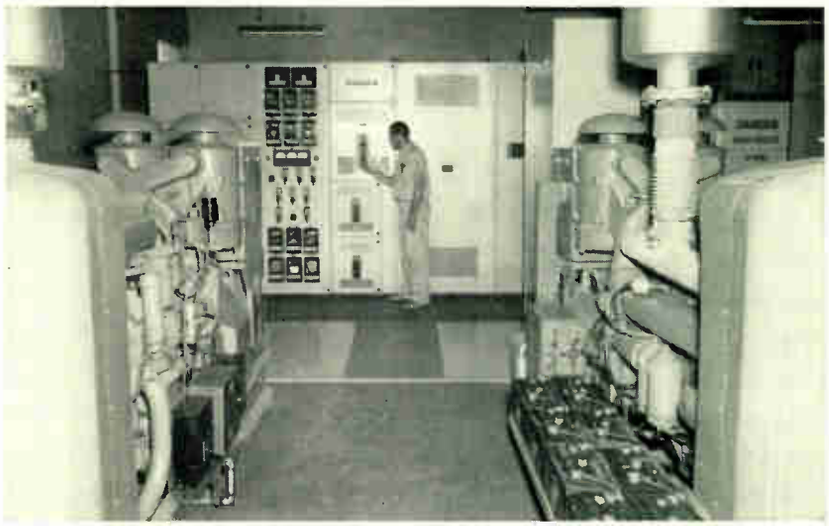
Where the duct must go around obstructions or turn corners, a flexible fitting using armored cable is used to join the two straight lengths. This flexible fitting can be bent in either direction, as necessary.

A unique system of interlocks provides several safety features. A sliding outlet cover can be moved only when a plug-in unit is in place on the duct. The plug-in unit has retractable stabs that make contact with the live bus bars only when the cover of the unit is closed. The cover cannot be opened while stabs are in contact with the bus bars.

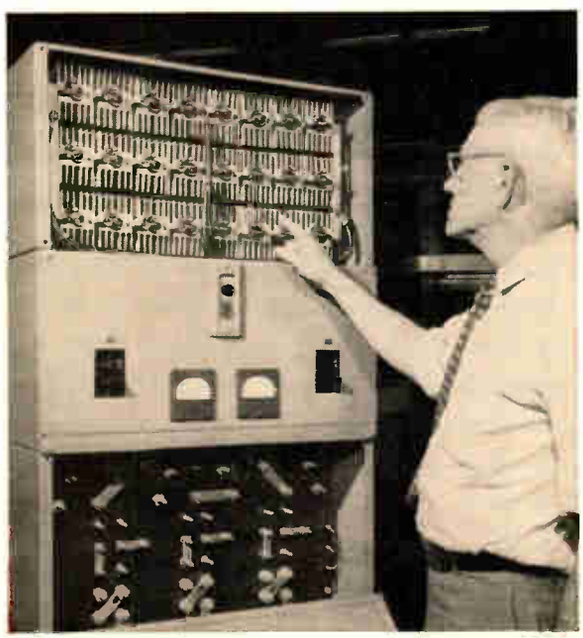
This new bus duct—called Uni-Bus—is made in ratings up to 800 amperes in one housing with copper bars, up to 600 amperes with aluminum bars, and up to 4000 amperes using parallel runs. ■



Turning corners is a snap with this new flexible fitting for bus duct.



This emergency power supply is designed to meet a critical need. It is located in the County of Los Angeles new Contagious Diseases Hospital unit, which provides services for the treatment of poliomyelitis. For those patients wholly dependent on artificial breathing mechanisms in respirators, doctors estimated that ten seconds was the maximum time that a respirator could be shut down. Thus this power supply is designed for emergency use in the event of power failure. Two diesel-generator sets operate automatically in parallel; power center at the rear is the "nerve center" of the control and distribution system.



Silicon diodes are working their way into many different applications. This is a new 50-kw rectifier power supply utilizing the new diodes. Primary use is expected to be as a power supply for d-c motor loads. Additional ratings are anticipated ranging from one to 100 kw.

D-C Mill Motor

■ Among motors, the heavy-duty mill type is like the 60-minute man in football—it has more stamina and is more rugged than most of its fellow motors. A new version of the heavy-duty motor is a little larger than its predecessors and has every inch as much ruggedness and stamina. This is the new 620 MC motor, an extension of the 600 series of silicone-insulated mill motors. It has the same features as its rugged counterparts—cast-steel, split-type frame, integral bearing and bearing housing assemblies, large diameter shaft between bearing supports, and

Motors

a compact mechanical design for dependability and simplicity of maintenance.

The new 620 motor is made in 275, 350, and 360 hp ratings, all with a 75 degree C temperature rise. Some of the first applications indicate the versatility of the new motor; it will perform as a processing motor in a pickling line, as a shear drive for a reversing slabbing mill, as a car-dumper motor, a shovel-hoist motor, an edger-roll drive on a universal roughing mill, and a barney-hoist motor in a sintering plant. The new design is built to meet AISE standards as to ratings and dimensions. ■

Improvements for Fractionals

■ While the "flyweight" class of electric motors—the small fractionals—can't match their heavyweight counterparts in size or brute strength, pound for pound they are as good as motors of any size. This year several of them improved their style and technique even further.

Induction Motor for Business Machines—Universal motors have many valuable uses, but in adding machines and calculators they sometimes cause too much radio and tv interference, and because of this their governor and brushes require too much maintenance. A solution to these difficulties is found in a new split-capacitor induction motor, small enough to fit in the same space as the universal motor. The new motor is essentially round in general shape, but has two flat sides. These flat sides reduce the overall height, thereby enabling the motor to fit in the rectangular space available in most adding machines and calculators. These flat sides, incidentally, necessitated an unusual punching design, with three different sizes of slots, to make maximum use of the available space. In addition to reducing maintenance and interference, the new induction motor has several other advantages; it does not create a fire hazard if locked on the line, it operates more quietly than the universal motor, and is less expensive. Two different sizes are made—1/40 and 1/20 hp at 3300 rpm and 115 volts.

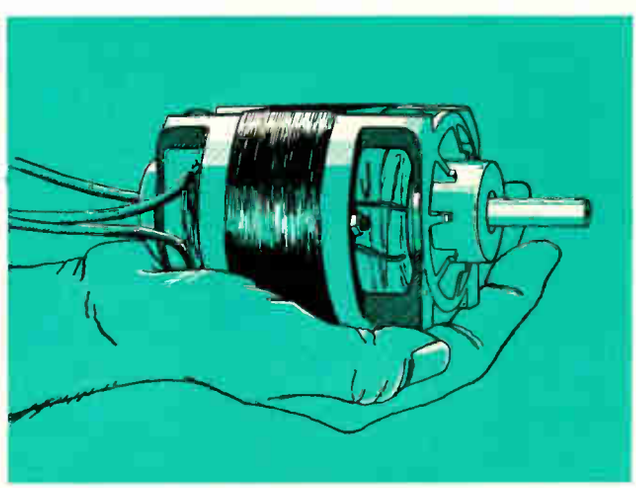
Shaded-Pole Motor—Flat motors—the flatter the better—are required in many fan applications, particularly for window fans. A new one is about the thickness of a cigarette. The new motor was accomplished by a redesign of the end shields and bearing assemblies of the previous shaded-pole motor. A unique new oil circulating system enables mounting the new motor in any position, including vertically, as is required on many fans. The motor is made in both open and enclosed versions, and in sizes from ten milli-horsepower to 1/8 horsepower. ■

More Lifeline Motors for More Uses

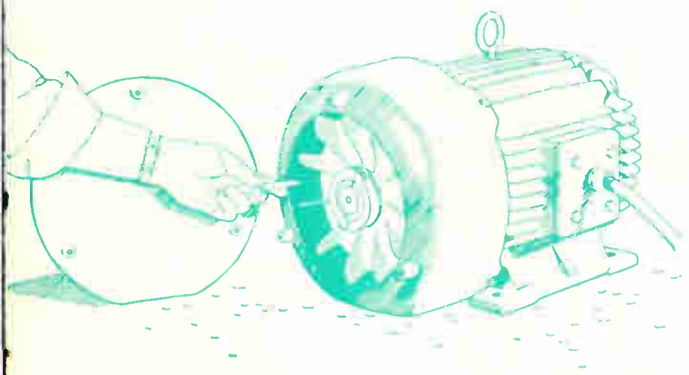
■ Last year the versatility of the new Lifeline A motor began to become apparent in a variety of motors for different applications, all "branches" of the same family tree. This year the soundness of the basic design became more apparent, with a number of new Lifeline motors.

Reluctance Motors—A machine for spinning man-made fibers has many parts that must rotate at exactly the same speed to obtain uniformity of yarn. Often the machine speed must also be adjustable to produce yarn of different deniers. The most common method of answering these requirements is by the use of synchronous reluctance motors, adjusting their supply frequency to obtain different speeds. The important characteristics of a synchronous reluctance motor are pull-in torque, pull-out torque, efficiency, and power factor. The new Lifeline A design has also proved extremely adaptable to improvement in these characteristics. The new line of reluctance motors occupies less space and has better performance than its predecessor. Spinning machines are but one use for the new reluctance motors; they are applicable in many applications requiring many small motors operating at precisely the same speed, with adjustable-frequency control.

New shaded-pole motor (below) is especially suited to fan applications because of its short length.



Two flat sides of this induction motor reduce overall height. The motor is designed for use in adding machines and calculators, and will fit in the same space as a universal motor.



This textile motor is designed to avoid lint problems.

Rapid-Reversing Drill Motor—Motors used for industrial drilling operations and similar functions often must be capable of reversing 40 times a minute or more. As industrial processes increase in speed and become more automatic, the demand is for more frequent reversal. This trend is taken into account in a new rapid-reversing a-c motor that is capable of 80 reversals a minute at no load. In part, this increase in capability lies in the fact that the new Lifeline A design inherently has better heat dissipating characteristics. In addition, in this motor the rotor is smaller, resulting in lower inertia. At present two sizes of these totally enclosed fan-cooled motors have been designed and tested—one and two horsepower, 1200-rpm ratings.

Textile Motor—Lint can be a major headache in textile mills. If allowed to work its way into machinery and electrical equipment it can cause all sorts of troubles. A new totally enclosed fan-cooled motor helps out with this problem. Basically the motor is similar to the standard fan-cooled motor. The major difference lies in the air passages.

Since the motor is totally enclosed lint can't work its way into the motor itself. The cooling passages have been streamlined and any obstructions eliminated that might catch the air-borne lint. Air is drawn into the entrance by a blower, then is directed out through the streamlined passage and over the exterior frame of the motor.

Eventually, this motor may replace the open-frame lint-free motor, which has been the standard textile motor for many years. In addition to the better protection afforded by the totally enclosed design, the motor utilizes standard types of windings, common to other Lifeline A designs, thus simplifying maintenance. Present ratings cover the range up to 30 horsepower. ■

This radically new vacuum-furnace design uses a water-cooled vacuum retort with electric-heating elements located inside the furnace itself. Because, in vacuum furnaces, most of the heat transfer is by radiation rather than convection, the new design places the heating elements inside, and uses radiation shields for thermal insulation, eliminating the refractory brick linings.

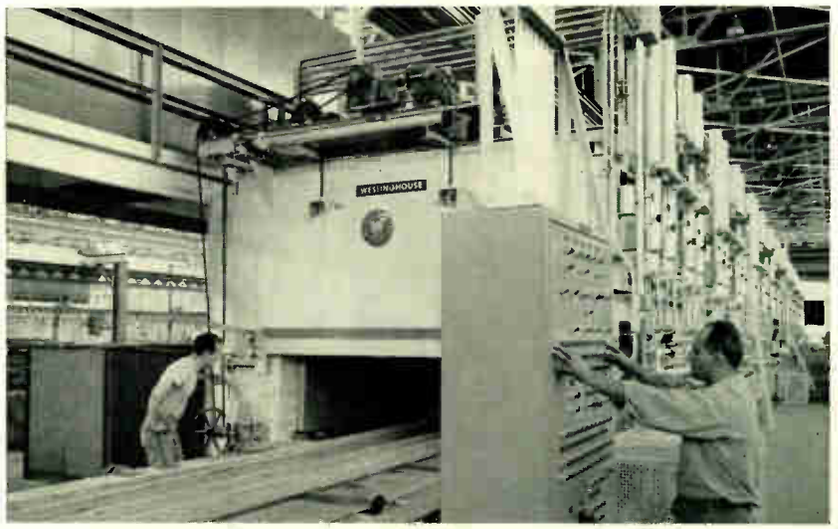
The furnace, shown at right in late stages of construction, will be used for vacuum annealing and degassing of titanium ingots and sheets. It has a rating of 450 kw, and a maximum operating temperature of 1600 degrees F. The charge chamber can be evacuated to one millionth of an atmosphere. With a charge space of 4 by 4 by 12 feet, it is the largest furnace of its type yet built.

Roller Hearth for Aluminum

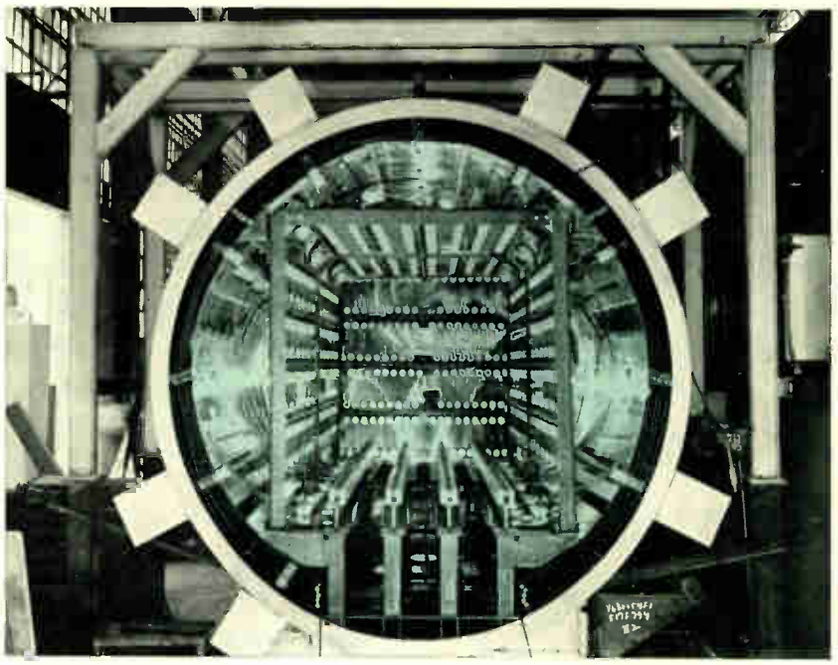
Industrial Heating

■ A lot of separate operations in the heat treating of large aluminum-alloy extrusions are eliminated in a new application of a roller-hearth furnace. Furthermore, the quality of the end product is improved.

Prior to the installation of this new furnace, extrusion heat-treating operations in this mill were handled in vertical furnaces, over vertical quenching pits. This meant that each extrusion had to be separately handled by hoists and cranes in lowering the piece into the quench and hoisting it into the furnace. With the new roller-hearth furnace, extrusions are brought to a 103-foot charging table by conveyor; charge doors raise automatically and extrusions go into the 112-foot furnace at the rate of 50 feet per minute. The furnace itself has a maximum operating temperature of 1000 degrees F, and a total rating of 7.5 million Btu per hour. During the heating cycle the furnace rolls oscillate. After the necessary heating and soaking time has elapsed, discharge doors open, and the extrusions pass through a 45-foot



Roller hearth furnace for aluminum heat-treating.



quench spray and onto the 104-foot runout table. This furnace is capable of handling extrusions up to 100 feet long.

Heat-treating time is about half that necessary in the vertical furnace used previously. Also, mechanical properties of the material, such as yield strength, are equal or higher than those obtained on the vertical furnace. ■

Lamp Progress

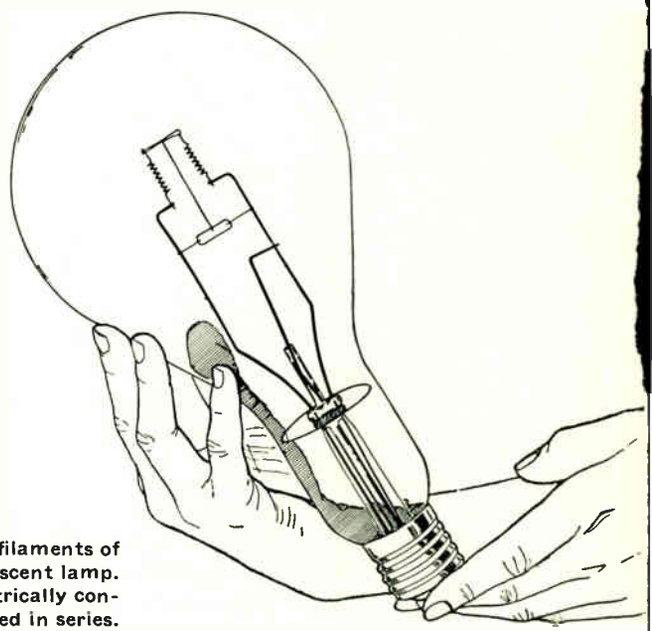
Lamps and Lighting

■ The demand for light in ever increasing quantity, and in improved variety and quality seems insatiable. General lighting levels are still on the increase; more light from individual sources, and a greater variety of light for purely esthetic purposes are the order of the day. The steady appetite for more light continues to produce improvements, both in quality and quantity, each year.

Incandescent Lamps—Despite the fact that they are the oldest electrical light source, incandescent lamps are still being improved. As an indication of the greater use of light in the home, the three-way lamp has about doubled in use in the past five or six years. A new one packs more light in a smaller bulb. A change from single-coil to coiled-coil construction brought about the space saving and enables packing more light into a smaller package. A new size is also added to the group of three-way lamps—a bulb arranged for 100- 200- and 300-watt operation, with a standard household-size medium base.

High-wattage lamps have a new filament design. To produce a greater light output over the span of life, the 1000-watt lamp now has two filaments, electrically connected in series but physically mounted vertically and in parallel. About 15 percent more light over the life of the lamp is accomplished with this construction, plus achieving a physically stronger lamp (see sketch below).

The possibilities for the use of light as a decorative medium are just now being realized in the home, although "colored" light has long been used commercially for display effects. The advent of three new tinted lamps for home use—in aqua, candlelight, and pink shades—gives the homemaker a new decorating tool. These colors are obtained by the subtractive method in incandescent lamps, i.e., by filtering out the unwanted part of the spectrum. Thus, in the pink lamp, for example, selective absorption decreases the percentage of blue and green to give a warmer tone. The filtering material is a fine, talc-like powder deposited on the interior of the bulb by electrostatic deposition.



Sketch shows parallel filaments of new 1000-watt incandescent lamp. Filaments are electrically connected in series.

New 1200-watt projection lamp (left) fits projectors designed for 1000-watt lamps. Older 1200-watt lamp (right) is far too large for this purpose.

Projection Lamps—Another case example of packing more light in a given space is found in a new projection lamp. This gets 1200 watts into the same space formerly utilized by the 1000-watt lamp. New techniques in wire drawing and processing—which produce a finer, stronger filament wire—are responsible for the improvement. The new lamp is expected to be especially valuable where long throw of light is necessary; one use is for the armed services, where films are often shown to large groups of people in such "theaters" as the deck of an aircraft carrier.

High-Speed Photography—A tremendous amount of light is poured into a very small area by a new reflector-type spot lamp for ultra-high-speed photography. This is designed to light an area two inches square to above 20 000 footcandles. This high light value is necessary because of the extremely short exposure time of the camera. In use, the lamp will go

on and off in synchronization with the camera; the lamp has a maximum burning time of 10 seconds on full voltage; two voltages are available, 28 and 115.

Four Headlights for Automobiles—A new approach to automotive headlighting is featured in some of the 1957 model cars. This is the use of four headlamps, instead of the usual two, which provides more light for both driving and passing; design developments in the lamps also provide greater seeing distance when passing.

In one four-lamp system, two lamps will be placed side by side in each fender. These lamps are slightly smaller than previous headlamps. The two outboard lamps each have a driving beam filament plus a passing beam filament. The inboard lamps are auxiliary to the driving beam filament of the outboard lamps; they have a single filament producing a spot to fill in the center of the spread light of the driving beam of the outboard lamps. When driving on country beam, four lamps are lighted, each burning filament being 37.5 watts. When passing, only the two outboard are lighted, each burning a 50-watt passing beam filament.

Fluorescent Lamps—A number of trends are apparent in the field of fluorescent lamps. For one, a steady improvement in lumen output has been achieved since fluorescent lamps were first introduced. Many factors have played a part in this improvement. A large portion of the progress can be attributed to advances in the manufacturing and processing techniques, better phosphors, and improved methods of applying them. The resultant gains, viewed in the long range, are impressive. The 40-watt, T-12 white lamp, for example, has almost doubled in lumen output compared to the first lamps of that type in 1939—a jump from about 1400 lumens to 2700. A gradual change in color preference is also evident. From a "standing start" right after World War II, the cool white lamp has become far and away the most popular fluorescent—amounting to from 60 to 70 percent of the total fluorescents sold. White, on the other hand, which once was in the same high spot percentage-wise, has dropped to a total of 10 percent of all fluorescent lamps.

Higher output from fluorescent lamps is accomplished with a new group of rapid-start lamps developed in 1956. These lamps produce about 40 percent more light than comparable sizes of standard lamps. Thus lighting level can be increased without increasing the number of fixtures required. This boost in output was accomplished by higher current loading.

Mercury Lamps—One answer has been found to special light problems where maximum light output per unit is more important than maximum life. By operating the standard 1000-watt A-H15 mercury lamp at 1500 watts, the light output is stepped up from 55 000 to 80 000 lumens, or 45 percent. This is roughly the equivalent of 2½ standard 1500-watt incandescent lamps. Tests indicate an average life of 2000 hours at this higher wattage. This operation at higher wattage is suitable for lighting auditoriums, large outdoor construction jobs, sports events, and similar applications.

A new high-output phosphor for fluorescent-mercury lamps enables a greater lumen output than the present "golden white"—even greater than an uncoated lamp. Initially this phosphor will be used on the 400-watt S-H7. The color output of this lamp is blue-white, which makes it suitable for many industrial and outdoor lighting applications. Its initial lumen output is 23 000.

Short-Arc Mercury Lamps—Short-arc mercury lamps answer a need for a brilliant "point source" of light that can be operated by remote control over long periods. The most significant use so far has been in searchlights of all types.

This year the life of the 2500-watt lamp was doubled—from 100 to 200 hours. This change was brought about by an improved double seal, and by a new electrode design. One unusual application of these lamps made this year was an installation of four searchlights atop the Empire State Building as a beacon. One of these beacons points straight up, the other three are directed outward at an angle of five degrees above horizontal. The three revolve counterclockwise at the rate of one revolution per minute. Powered by 2500-watt short-arc mercury lamps, these beacons are powerful enough to be seen as far away as Boston or Baltimore. ■

Mercury Lighting Moves into New Areas

■ Mercury-vapor lamps have been gaining steadily in popularity for streetlighting. Two new luminaire developments will help to extend their advantages to new areas. One of these is specially designed to enable mercury lighting to move into residential zones. The luminaire uses a combination of a highly

This modification of the OV-35 luminaire is for series streetlighting circuits. It is designed for use with 400-watt color-corrected mercury lamps.

polished alzak reflector and a prismatic glass refractor to produce a narrow, high-candlepower distribution well suited to the wide pole spacing and narrow streets of residential districts.

Residential streetlighting requires two distinct beam patterns—one luminaire with two beams for use in the middle of the block, and a second type with four beams for use at corners. Engineers solved this problem by using the same reflector for each type, and modifying the glass refractor, so that for corner use a beam of light is produced for each of the four streets at intersections. The new luminaire, called the OV-10, accepts the 100-watt (L-H4) and the 175-watt (A-H22) clear mercury lamps. The new fixture allows low-wattage (i.e., 100 and 175 watt) mercury lamps to be operated with the arc tube horizontal for the first time in street-lighting. This enables most efficient use of mercury lamps and better optical control.

The new OV-35 luminaire can now be used on straight series streetlighting circuits. Called the OV-35S, it is designed for use with the 400-watt color-corrected mercury lamp. It can be installed directly on either 6.6- or 3.3-ampere series circuits.

The new luminaire has the identical housing and appearance as its running mate for multiple circuits, the OV-35. However, the OV-35S incorporates a high-voltage of 19 000 volts. Safety for maintenance personnel is assured by attaching the film cutout holder directly to the luminaire door so that the series circuit is shorted and the film cutout removed whenever the door is open. Like its counterpart, the new luminaire has a completely sealed optical system. ■

High-Production Welding with CO_2

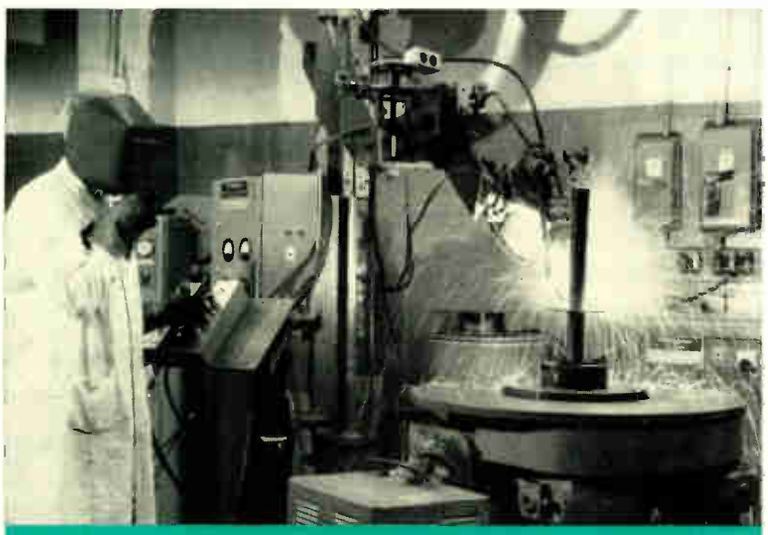
Welding

■ Mass-production lines require the ultimate in heavy-duty equipment, with a minimum of maintenance. Welding equipment is no exception. A new automatic arc welder fulfills these requirements, making use of the new CO_2 welding process.

Production-line welding, in general, has used submerged-arc welding until now. In the carbon-dioxide method, the powdered flux used with a submerged arc is replaced by a jet of carbon dioxide, which floods the weld area, protecting the weld deposit. The new method eliminates most of the equipment maintenance since no abrasive flux powder is introduced to cause wear on moving parts. Also flux-handling equipment is eliminated.

The new CO_2 welder is an outgrowth of the new inert-gas West-ing-arc process introduced about two years ago. Since that time two new welding heads and controls have been developed, and the process can now be used for inert gas, carbon-dioxide or submerged-arc welding. One, known as the SA-40, provides automatic operation with the CO_2 process, and can be used with the submerged-arc process if manual inching of the welding wire to touch the work, and manual flux dumping can be employed. The second unit, the SA-40A gives fully automatic inching, flux dumping, and arc starting on submerged-arc welding as well as with CO_2 welding.

The welders used with the new controls have been increased from 500 to 600 amperes to obtain maximum welding speeds. The unit is designed to meet JIC standards, and has plug-in cables and panels. ■



New automatic arc welder, shown in action, uses the new CO_2 welding process. Two new heads and controls have been developed.

Silicon rectifiers bring many advantages to arc welding. Shown here are typical selenium stack and comparable silicon rectifier (at right). Note the size difference.

Silicon Rectifiers Take Up Welding

■ D-c arc welders have run the gamut in the way of power conversion. First came motor-generator sets to supply the direct current, then selenium rectifiers took over the job, providing the first static source; next germanium rectifiers came to the fore. Now silicon rectifiers are used in a new d-c arc welder.

Silicon rectifiers supply power with phenomenal efficiency. On heavy current consuming applications such as arc welding, the reduction in power loss amounts to a substantial saving. Welding performance is raised to a new high. Silicon forms almost a perfect barrier to reverse current flow, thus elimi-

nating dissipation of transient energy pulses produced in the welder and improving the dynamic welding characteristics. And while other types of rectifiers are limited to operation at moderately low temperature, silicon has the unique ability to operate at temperatures up to 375 degrees F.

In addition to these qualities silicon has almost unlimited life span, as a result of non-aging characteristics and the fact that the active element is enclosed in a hermetically sealed copper capsule.

A-c/D-c Welders—Silicon diodes have also found their way into a new group of a-c/d-c welders, where their advantages are equally apparent. The new welder is instantly convertible from a-c to d-c operation by a simple flick of a switch.

The unit consists of a main transformer, a saturable reactor for controlling the welding current, a single-phase, full-wave-bridge silicon rectifier for converting a-c welding output to d-c, a d-c stabilizing or smoothing reactor, and the necessary switching components. A change in the control current by means of a hand- or foot-operated rheostat changes the impedance of the reactor and thus controls the welding current. A special high-frequency unit, for mounting on top of the welder, makes the unit suitable for inert-gas arc welding. ■

Tubes For Television

Most significant development in color television during the past year has been the development of an all-glass envelope, 22-inch rectangular color television tube. The tube uses the conventional shadow-mask system, but eliminates many of the glass-to-metal seals that have been necessary on previous designs. In the new all-glass tube, after the three-color phosphor has been applied to the face plate and has been fitted with its shadow mask, the face plate is sealed directly to the cone using an electric arc-sealing process similar to that used for black-and-white bulbs.

Besides providing a less expensive type of bulb construction, the direct glass-to-glass seal also eliminates the insulation problems that accompany tubes using metal sealing techniques on metal cones. Since in tubes using metal the metal shell operates at a high potential, more elaborate means are required to insulate it from the set chassis. Problems remain to be solved regarding the economic manufacture of this all-glass tube. Also it is very apparent that color television has not been accepted by the public as readily as was anticipated.

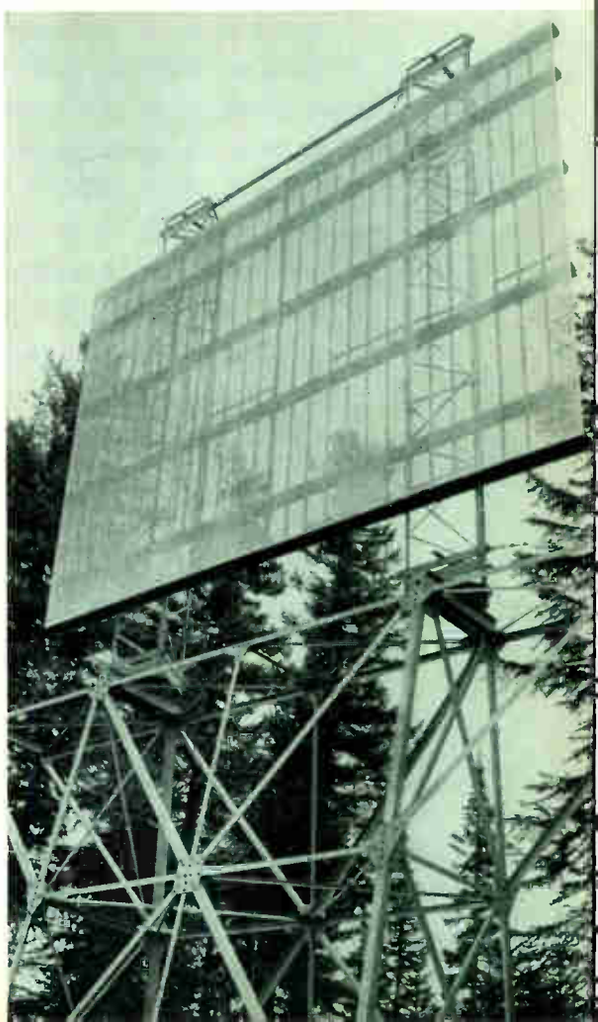
Black-and-white television picture tubes continue to show improvements. There has been a particular trend toward "portable" television sets using picture tubes as small as eight inches. The principle of 90-degree deflection, developed to keep large picture tubes as short as possible, has made portable-size tubes more practical. Best compromise so far seems to be the 14-inch tube, which is not prohibitive in weight, and provides an adequate picture for viewing.

A recently developed line of 90-degree deflection tubes—14, 17 and 21 inch—with a special electron gun with improved modulation characteristics, reduces the demand on the video output tube.

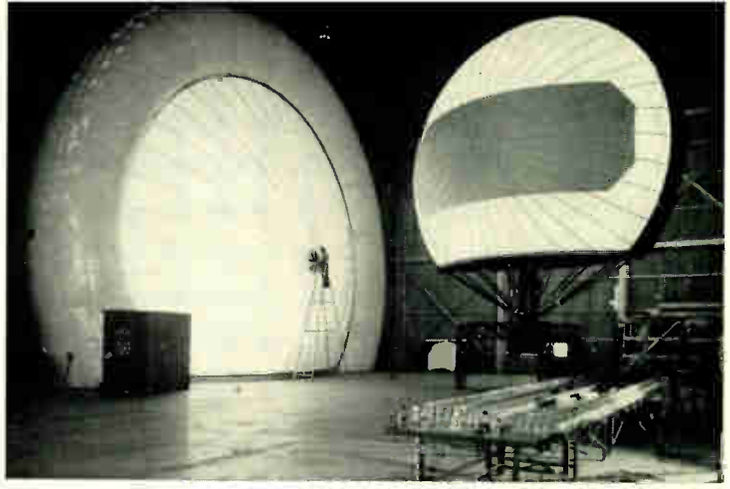
Meanwhile, back in the set . . . There have been a number of receiving tube improvements, chiefly for use in television receivers. A vhf amplifier tetrode (6CY5) was introduced for receivers to increase picture quality by reducing snow, thereby giving a clearer picture. Spacings of the tube parts and tolerances of assembly were greatly improved to achieve the desired result. These improvements are expected to be incorporated in all types of receiving tubes.

A new r-f pentode, type 6DK6, has been developed to give high gain in the intermediate-frequency amplifier of a television receiver. Using this tube, it is possible to design economically priced tv sets with only two stages of IF instead of the usual three. A new damper diode (12D4) was developed with higher current ratings than previous tubes, and gives an increase in B+ boost voltage and current. A new vhf cascode amplifier (4BX8) has been developed for r-f amplifier use in low B+ television tuners.

For the automobile . . . The 12-volt automotive system and the transistor have led to a hybrid combination of transistors and newly designed receiving tubes able to operate with a plate-voltage power supply of only 12 volts for automobile radio receivers. The complete radio receiver can thus operate directly from the automotive lighting system, and a vibrator, rectifier, power transformer, and several small components have been eliminated. A Westinghouse development of importance in this field is the IF pentode type 12DK5. ■



There's more than one way to get to the other side of a mountain! This passive reflector bounces microwave signals around a mountain and up a narrow river canyon, thus avoiding the installation of a repeater station on top of the mountain. The Portland General Electric Company uses a microwave system to control the gates at their Timothy Meadows storage reservoir from their Three Lynx generating plant about 12 miles downstream. Heavy snows and ice ruled out telephone lines, and the lack of existing power lines eliminated the possibility of using power-line carrier. The use of microwave and the passive reflector has solved the problem neatly. The reflector, some 20 by 28 feet in size, is located 6 miles from one terminal and 10 miles from the other. Constructed of perforated aluminum sheets on an aluminum frame, it is mounted on a steel support to raise it above the 20-foot snow drifts common during winter.



An extremely lightweight, mobile radar set of revolutionary design and long range has been developed for the U.S. Air Force. The key development is the radar antenna: two paraboloids—one of which is coated on the inside with vaporized aluminum to form the radar reflector—are joined at their rims and inflated. Called the Paraballoon antenna, this radar was developed to detect high-flying aircraft and to play a vital role in strengthening the defence networks of America and its allied nations.

High gain is synonymous with large reflector size. The first Paraballoon antenna (right) contains an aluminum reflector that is 30 feet long and 20 feet wide. Fifty-foot units (left) now on order—for the U.S. Air Force and for the U.S. Marine Corps—will have reflector surfaces 50 feet long by 40 feet wide.

"Scattering" UHF

■ The transmission of ultra-high-frequency radio energy to distances beyond line-of-sight would permit many new applications of communications systems. Long-distance uhf transmission could be accomplished with fewer relay stations, thus reducing equipment maintenance and permitting uhf transmission over areas where placement of relay stations is impossible. While transmission over comparable distances is presently possible at lower frequencies, longer distance uhf transmission would alleviate the crowded lower frequencies and use the wider bandwidths available at high frequencies.

Beyond-the-horizon transmission was considered impractical until the late forties when unusual uhf propagation phenomena were observed. Further investigation has shown previous theories to be inadequate and new theories have evolved to explain uhf reception at beyond-the-horizon distances. The most popular is the *tropospheric scatter* theory.

Briefly, this theory states that humidity and temperature of the atmosphere vary at randomly spaced intervals, causing proportionate variations in the dielectric constant of the atmosphere. When uhf radio energy strikes these variations, the energy is scattered in a manner similar to scattering of light by a clear glass marble. While the amount of energy scattered from the troposphere back to earth is small, it is still possible to utilize this transmission phenomenon by radiating a large amount of uhf radio energy in a concentrated beam.

This is the approach being used by electronics engineers in a study to determine practicability of beyond-the-horizon uhf transmission. A high-power transmitter and a highly directional antenna beam large quantities of radio energy toward the receiver. A directional receiving antenna then gathers the small amount of scattered energy available at the receiving site located nearly three hundred miles distant.

Although the results of scatter transmission are still open to question, the possibilities are most intriguing. Long distance uhf communication could be utilized for commercial communications as well as military; it is even possible that scatter propagation could provide a means to link continents for international television. ■

Invisible Highway of Sound for New Kansas Turnpike

■ An "invisible highway of sound" will control administrative, maintenance, and police operations along the 236-mile length of the new Kansas Turnpike. A uhf multi-channel radio system spanning the entire length of the highway will provide instant and reliable communications between all operating units along the road. The microwave system includes two terminal stations and nine repeater stations located approximately 20 miles apart along the length of the toll road, plus fixed and mobile transmitting and receiving equipment. Four separate circuits will be used for two-way communications.

The headquarters for the turnpike operations in Wichita will be "connected" to the two maintenance divisions and each of the six maintenance shops by a microwave party-line telephone. Each of the fixed locations on the party line will be able to communicate with any of the other locations. In addition to the party-line telephone serving these locations, each major piece of maintenance equipment, as well as administrative vehicles, has a mobile radio unit. ■

Land, Sea, and Air

Magamps Go to Sea

■ The propulsion controls of three ice-strengthened cargo ships will use Magamp regulators. They will replace the rotating regulators or electro-pneumatic devices used previously. Actually, Magamp regulators will perform two functions on these new ships. They will control the propulsion motors, to adjust their operating characteristics automatically between open-water conditions and operation in thick ice, permitting maximum horsepower to be developed without overloading the engines. Also, they will provide follow-up control, permitting control of the propulsion machinery from the pilot house. This means that only small-diameter control wiring will be needed between the pilot house and the engine room. On these ships this is of particular importance, since control of the ships in ice-filled waters is often accomplished from a remote station, located on the forward mast of the ship. Space limitations at this remote station are severe; the use of Magamps help relieve the congestion.

Of special importance in this type of service, of course, is the fact that Magamps are completely sealed, and thus oblivious to the ever-present vibration and moisture. ■

Aircraft Electrical Systems

■ Last year on these pages, we described a new oil-cooled brushless a-c generator for aircraft, which gained its d-c field from a bridge of silicon rectifiers mounted on the shaft of the machine. This year, that generator has a new running mate—an air-cooled unit. The new generator produces three-phase power at 400 cycles, 208/120 volts. The machine is driven by a constant-speed drive. Excitation power is fed to the shunt winding on the exciter stator poles from a Magamp regulator. The three-phase power generated in the rotating exciter armature is fed to a three-phase full-wave bridge of silicon rectifiers mounted inside the shaft. D-c power from the bridge is fed to the main rotating field. The main three-phase power is generated in the a-c stator. Both 30- and 40-kva ratings are now designed and in production for the Boeing 707 jet liner.

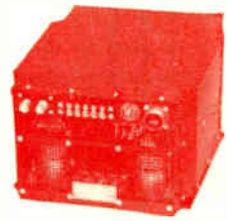
Magnetic-Amplifier Voltage Regulator—Teaming up with the new brushless generators is a Magamp regulator that controls their output voltage. The new regulator not only handles more power output per pound than previous units, but also maintains more accurate control. Its weight is 10 pounds compared to 14 for its predecessor, and it has a continuous output of 65 watts compared to 45 for the previous unit. The new regulator controls the output voltage to within ± one percent over the rated load and frequency (±5 percent) range; also it controls voltage to within ± two percent over the rated load and frequency range, and in a temperature range of from −55 degrees C to +71 degrees C, from sea level to 65 000 feet. It will handle generators rated from 20 to 60 kva.

Transistorized Control and Protective Panel—Still another running mate for the brushless generator and the Magamp voltage regulator is a new transistorized control and protection panel for parallel a-c aircraft electrical systems. The control and protection function are performed by static sensing circuits and logic circuits that provide signals through transistor amplifiers to open or close a generator control relay, generator circuit breaker, or bus-tie circuit breaker. This unit replaces a relay package containing several different types of relays. Elimination of the multitude of relays adds considerably more reliability to the unit. The new panel can be used in three-phase, single-generator or parallel aircraft systems, and although designed for use with 30- or 40-kva generators, is equally suited to other ratings.

Transformer-Rectifier Units—In addition to enabling a practical brushless generator, the advent of silicon power rectifiers has brought other advantages to aircraft systems. For one, it has made possible much improved transformer-rectifier units for providing d-c power. Previously, d-c power could be supplied by one of two means—a d-c generator, or by a transformer rectifier utilizing selenium rectifiers for conversion.

Silicon offers significant advantages over both. Importantly, it permits higher temperature operation, with a concurrent reduction in size and weight.

A new line of regulated and nonregulated transformer-rectifier units has been developed for high-temperature applications. They convert 200-volt, 400-cycle, three-phase power to 27 volts d-c power with 12-phase output voltage ripple characteristics. Regulated units use 12-phase self-saturating magnetic amplifiers to regulate the voltage applied to the silicon rectifiers. One special 6-phase regulated design capable of withstanding 40 g's vibration has been developed for a guided missile. Typical standard ratings for conventional military or commercial aircraft are 200, 150, 100, and 50 amperes d-c, either regulated or nonregulated. ■



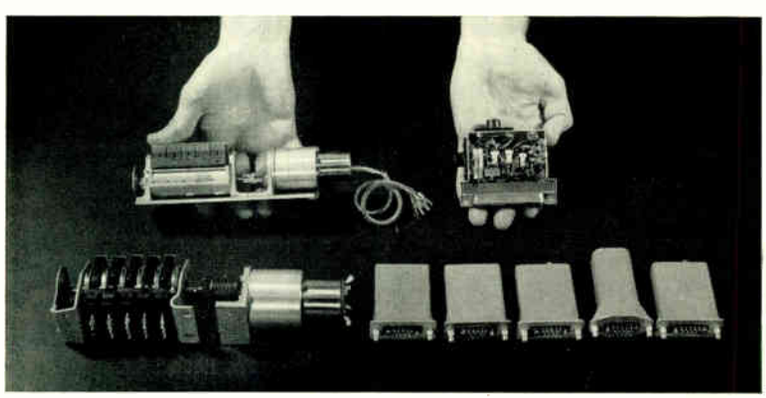
Three transformer-rectifier units. Top to bottom, a 200-amp regulated unit, a 100-amp regulated unit for guided-missile use, and a 150-amp non-regulated unit.

Airborne Computers Reduce

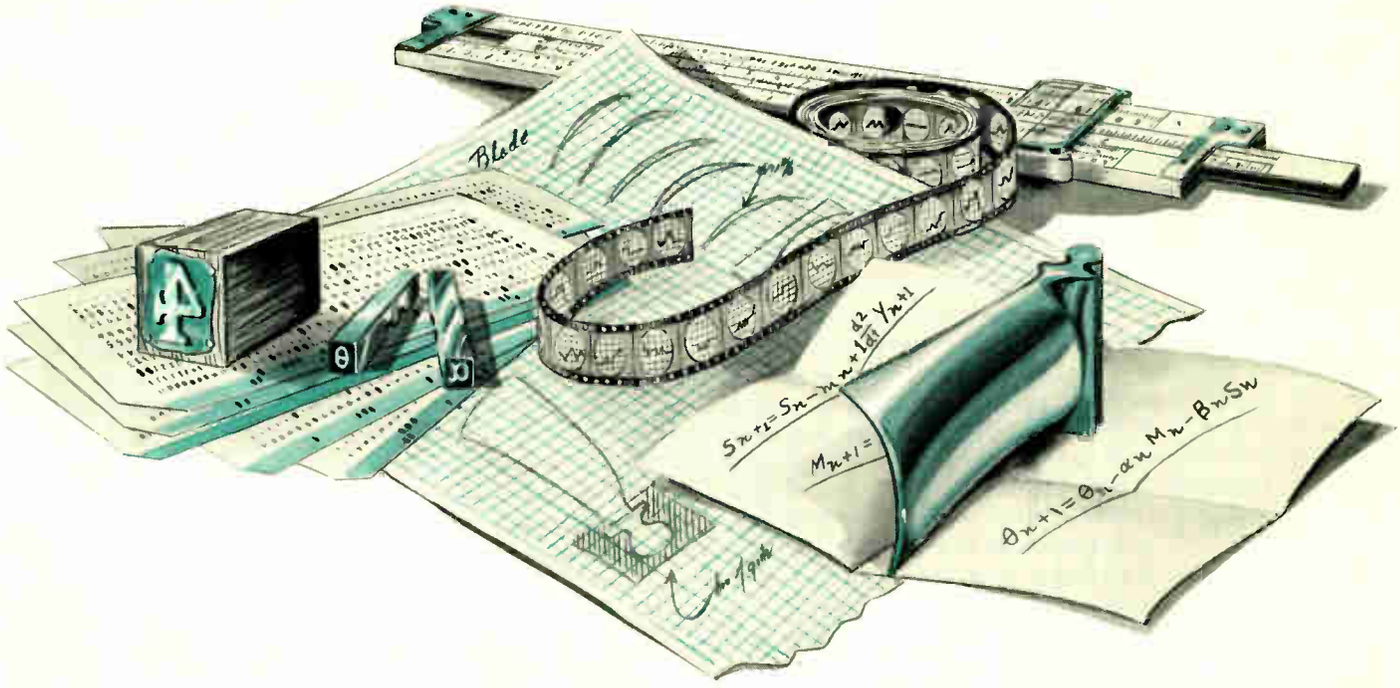
■ Airborne computers, the devices that from radar information predict target position and direct guns accordingly, are also on a weight and size reduction program. WETAC (Westinghouse Electronic Tubeless Analog Computer) is a typical example. A major element of this computer, the instrument servo, consists of an amplifier, servo motor, gear box, and a bank of potentiometers.

Weight of the servo amplifier was reduced from 33 to 4 ounces. The new all-transistorized amplifier replaces five molded units using vacuum tubes. The transistors are silicon to operate through a wider temperature range, and the amplifier also employs a feedback loop to correct for any temperature deviations in transistor characteristics. Another advantage of the transistorized circuit is the low power consumption. This is especially true during nulls, when the power consumption of the transistorized amplifier is about one watt—the previous system required 40 watts.

Size reduction was also aided by fewer total components—39 for the original version to 24 for the transistor servo. This includes such items as resistors, capacitors, diodes, and transformers. For example, six tubes in the original version have been replaced by five transistors. ■



This airborne computer has undergone a reduction in both size and weight. The old version had a volume of 25 cubic inches and weighed 25 ounces. The new model occupies but eight cubic inches, weighs 10 ounces.



Research and Development

Electroluminescence—Light Source of the Future

Electroluminescence—man's newest light source—will bear watching. If it lives up to its potential, it may well create entirely new concepts in lighting. Assuming that no serious technical roadblocks crop up, the possibilities for this new light source are almost endless.

Consider. Electroluminescence is light emission from phosphor powders embedded in an insulator, excited by an a-c field. Note that no mention is made in this simple definition of the bulbs or tubes common to other light sources. In a demonstration at the dedication of the new Westinghouse Research Laboratories, an entire room was lighted by flat electroluminescent panels on the ceiling and three walls. These panels were one-foot-square flat glass plates coated with a plastic containing the phosphor, and topped off by an aluminum conducting coating. Hooked up to a source of power these plates had a brightness of 100 foot lamberts. This was the first full-scale demonstration of this new light source.

But there's more to electroluminescene than the fact that light is produced by a flat panel. For one thing, the color can be varied. Some phosphors have more than one emission band, and changing the frequency means a change in color. For example, the phosphor used in the demonstration room produces green light at frequencies below 1000 cycles. When the frequency is above 5000 cycles, the light emitted is blue; in between, it can be varying shades of blue-green. White light is obtained by mixing red, blue, and green phosphors, so it is entirely possible that control of color in a room, as well as control of brightness, could be achieved simply by twisting a knob. Electroluminescent lighting is versatile in another way, too. It is not restricted to flat planes, as in the demonstration room, but could be made into a variety of shapes.

The practical everyday use of electroluminescence is not yet here. But if progress continues as rapidly as it has in the past two years, that day is not far off. The phenomenon of electroluminescence was discovered by a French scientist, Georges Destriau, in 1936; in 1947 he published a technical paper on the

Variety of electroluminescent panels, each no thicker than window glass, provide the light for the photograph at left. Colors include red, blue, orange, green and white. At right is a room with walls and ceiling made of many individual electroluminescent panels.

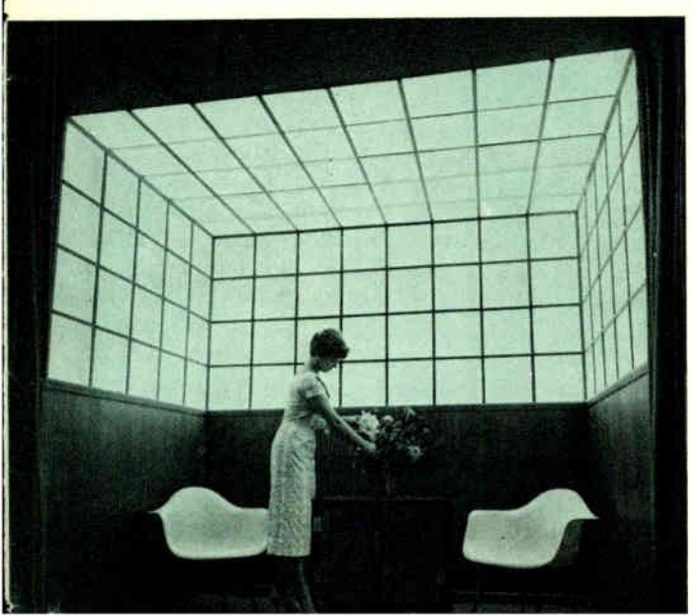
subject. The following year Westinghouse began research in this field. Early electroluminescent panels were both exciting and discouraging. They showed clearly that the principle worked, but the light from them was so dim that it could only be seen in a darkened room. Progress has been rapid in the past two years, however. The brightness has been increased to the point where it can now exceed that of a 40-watt fluorescent lamp. Among the factors that must be improved, however, is efficiency. The present maximum efficiency in lumens per watt is 9, compared to 16 for incandescent lamps and 60 to 70 for fluorescent lamps. Conversely, however, herein lies one of its most promising features. Scientists predict a maximum future efficiency of 240 lumens per watt for electroluminescence, whereas incandescent lamps are limited to 22 and fluorescent to 100 for maximum potential values. The highest efficiency obtained, i.e., 9 lumens per watt was achieved at a specific voltage power and frequency level. Lowering or raising either value decreases the efficiency; thus much of the improvement in this direction will likely come from improved phosphors.

The possible uses and advantages for electroluminescence at this stage are limited largely by the imagination. The easy switch from one color to another, for example, would create an entirely new field for decorative lighting, both in the home and commercially. The places in which light could be placed would no longer be limited by the size of the lamp and its fixture. Space could be saved, especially in commercial buildings, since the glass panel of electroluminescence is less than a quarter inch thick, and many times that must be allowed in vertical space for lighting in most buildings. And so on.

This is the state of electroluminescence today. When—or perhaps whether—it will come into widespread use depends largely upon how rapidly and how well scientists and engineers are able to untie the remaining technical knots. At present, however, the possibilities are promising. ■

Super-Frequency Radar and Superconductivity

■ The highest frequency microwaves ever generated by man are being used in conjunction with some of the lowest temperatures in the world to find out more about the property of superconductivity.



Materials in a superconducting state have remarkable properties. Best known is the ability as a perfect conductor, i.e., current once started in a ring of material flows indefinitely. The "why" of this behavior is still a riddle.

Since electrons are the carriers of electricity, those in a superconductor must be in a special state, i.e., one in which they can move about with no friction. Physicists have speculated that they may be condensed out of the state in which they normally move through the metal. The microwave experiments, plus others conducted at the Research Laboratories, show that there is a condensed electron state in superconductors.

In the microwave experiments, super-frequency waves are used to bombard a superconducting metal, such as aluminum or tin, that is held at a temperature of less than one degree above absolute zero. The waves are absorbed by the metal, which soaks up enough energy to lift its electrons from the superconducting to the normal conducting state. Measurements are made of the energy required for different temperatures of the metals. These experiments require precise frequency and power. One example: in a typical experiment the microwave power absorbed by a superconductor is only about a millionth of a watt. This tiny amount of power raises the temperature of the superconducting metal about one hundredth of a degree. ■

Seeing in the Dark

■ The human eye is an instrument that covers an enormous range of light intensities; but at the lowest level of illumination, such as under starlight conditions and lower, the eye's performance is limited by the particle nature of light itself. Electronics is stepping in to help out in this situation.

A striking example of the advantages that can be gained by electronic devices is a new image multiplier, now in the development stage. The eventual gain in brightness possible with this tube is from 10 to 20 *thousand*. Or, to put it another way, when full amplification is achieved, one light photon in every ten could be recorded by a camera focused on the output end of the tube, compared to the one photon in every thousand now registered by photographic plates used in astronomical observations. This then, would represent an improvement by a factor of 100 in the efficiency of present telescopes. Thus this new tube, in conjunction with present telescopes, should enable us to see further, or more clearly, into outer space, and study galaxies beyond the range of existing methods. Photography at low light levels, and military applications are other possible uses of the new experimental tube.

In the tube itself, an incoming photon of light strikes a photoelectric surface deposited on the entrance window, ejecting an electron. This electron is accelerated electrically until it hits the first multiplying stage, which is a thin electron-emitting foil. One incoming electron causes three or four electrons to be ejected from the other side. These are in turn accelerated to the next stage, where each one releases several more electrons. After about six re-

peated multiplication processes, a few thousand electrons are obtained for each one that was initially released from the photoelectric surface. These electrons are then made to strike a phosphor surface, causing it to glow and produce the original image greatly brightened.

The tube itself is only about three inches long and a little less than three inches in diameter. The effective diameter of the stages is about one inch, and the separation between stages is ¼ inch. The multiplying films themselves are only about two millionths of an inch thick. Actually they are a "sandwich," consisting of a fine copper mesh for mechanical support, a layer of glass-like material, a few atomic layers of gold, followed by potassium chloride.

Another example of electronic devices now in the development stage is a new television camera pickup tube. The tube—called the Ebicon (electron bombardment induced conductivity)—gives promise of being 100 times more sensitive than present television camera tubes. As particles of light strike the tube, they produce electrons, which are then accelerated by a potential of approximately 20 000 volts. These electrons are then shot through the key point of the tube, a storage target, consisting of a small aluminum-coated metal screen and a selenium semiconductor. This target serves the dual purpose of storing and multiplying the electrons.

Through this multiplication process a signal is received that is large enough to operate conventional electronic amplifiers. The tube itself is of simpler design than the sensitive tubes now in use and will require less complex associated camera equipment. Also, fewer camera adjustments will be necessary during operation.

The whole program of investigating better means of seeing in the dark has many ramifications. Many advantages would accrue from devices capable of improving on the visibility limit. The uses in astronomy, military applications, and photography are but a few of the possibilities. ■

Computer Developments

■ The "blue sky" idea of a factory guided by a computer "brain" involves many separate and knotty problems. However, engineers are making significant progress on several of them. For example, they are programming design procedures and calculations to fit modern high-speed digital computers, such as the IBM 704. At the same time manufacturing engineers are off to a good start in developing procedures for eventually adapting complete manufacturing processes to computer direction.

Many core-form transformer designs can be completely done by computer techniques; computers are being used in design work on inner-cooled turbine generators, and a computer program for the design of a complete line of large induction motors is being developed. As a result, the caliber of work done by design engineers will be elevated considerably. More time can be spent on the advancement of designs, or on the unsolved or unsatisfactory phases of design. Engineers will be able to work on problems that they just did not have time for before. This is all especially important in view of the growing amount of engineering talent demanded by our increasingly technological age.

A special study group is busily investigating means for processing manufacturing paper work on the UNIVAC, an electronic data-processing system recently installed at the East Pittsburgh plant. Such a system would carry out the paper work for the complete manufacturing process: initial manufacturing information would be prepared, followed by bills of material, weekly pay cards, and store-room pull cards. Flow of material and parts would be scheduled through the plant, and costs and inventories figured and recorded simultaneously.

The eventual aim would be the use of computers to integrate the functional activities of a manufacturing plant, including design work, paper work, and the various phases of manufacturing.

Furthermore, equipment designers and manufacturing engineers stand to gain from each other in the process. For example, a design engineer often does not know the final cost of certain components until the complete machine has been built, and all of the accounting summarized. Consequently, he cannot effect savings immediately for succeeding designs of similar equipment. However, with a computer following manufacturing phases day by day, costs would be immediately recorded for any component, and could be returned to the design engineer. Hence, a rapid feedback of manufacturing cost information would be provided, which could be immediately applied advantageously to succeeding designs.

Conversely, by utilizing computers with a complete storage of all standard component parts, a design is arrived at that has been optimized from a standpoint of the best possible performance, but which can be manufactured at the lowest possible cost using standard parts and components.

Design Engineering for Motors—A high-speed computer can result in a complete rearrangement of a design philosophy. For example, designers of induction motors have previously determined design constants, and then calculated performance to see if the required specifications have been met. If the necessary specifications have not been accomplished, the designer must then change some of the parameters and make another performance calculation. Hence, it has been something of a trial-and-error process, which has required that the design engineer exercise all his previous knowledge in making the proper design changes. Naturally, from a time standpoint, it has been impossible for the engineer to try all of the possible combinations.

In the program now being developed for computer design of induction motors, the computer will first determine an area of possible designs, described by the specifications—efficiency, power factor, pull-out torque, etc.—within which all acceptable designs can exist. The computer then starts a step-by-step process, and because of the extremely high speeds of calculation possible, can try a wide range of combinations, thereby optimizing on the best possible design.

Transformer Design Via Computers—During 1956 a number of core-form transformers were designed by a digital computer. To obtain the new design,

the design parameters are fed into the computer, which selects the exact quantities and arrangements of iron, copper-insulation, and cooling equipment.

This situation is not, of course, arrived at overnight. For many months transformer and computer engineers have been working on the programming to permit this design by computers. The method initially covers 1000 to 15 000 kva standardized SLS transformers, but will be extended to other sizes and types as programs are completed.

The prime advantages of this new method are time and accuracy. The time advantage is sometimes as great as 200 to 1. And, of course, the design engineer is freed from the necessity of routine design, thus allowing him more time for creative design.

Solving Transformer Design Problems—The determination of impulse or lightning voltage distributions within the windings is a tedious, time-consuming hand calculation for the design engineer. Now computers lend a hand. The designer fills out a form giving the dimensions of his transformer design. These dimensions are punched on an IBM card and the card fed into the digital computer. This calculates the coefficients of the differential equations involved. The differential equations are then solved on an analog computer, which gives the various voltages in the winding as a function of time.

This new method is now being used in the design of the large shell-form power transformers. Its first significant application was in analysis of the surge voltages on a huge 400 000-kva autotransformer, the largest transformer of this type ever built.

Simulation of Step Regulator by Computer—Tap changer operation can be analyzed and evaluated by two methods—by lengthy analytical techniques, or by measurement in the field. Field tests are valuable, but they take long periods of time, and often all the variables cannot be controlled.

Analog computers are taking over this function. An analog of the tap changer and control can be set up on the computer and all the variables, such as input voltage, step size, and the various control settings, can be controlled.

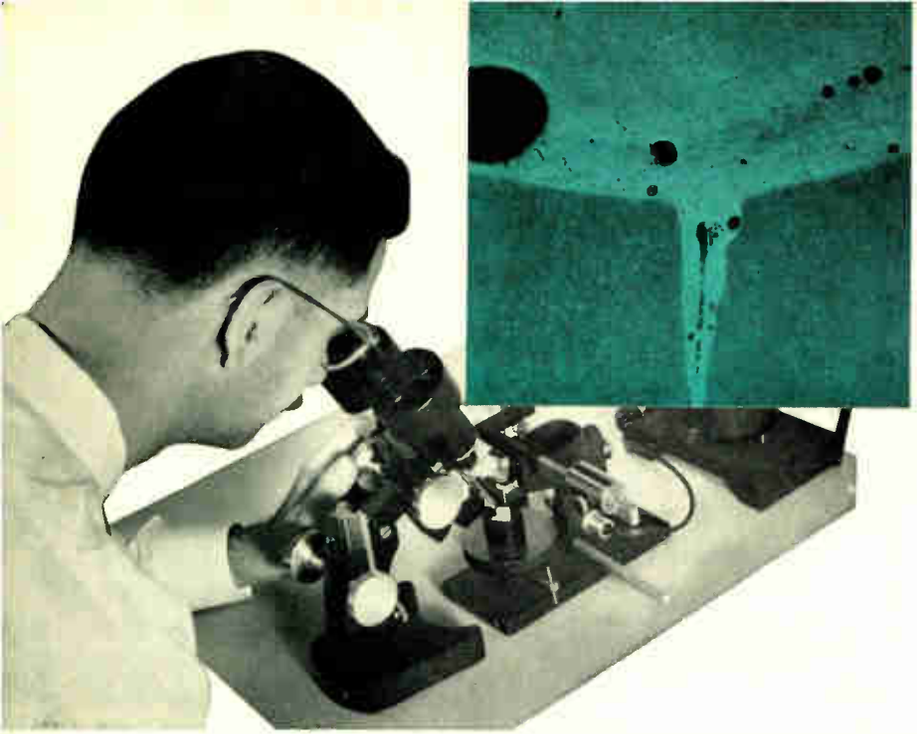
One project planned is the determination of the optimum step size for regulators. In addition to analysis and evaluation of present designs, the new method will be used as a design tool for development of new controls and tap changers.

Determining Jet-Engine Performance—Another area in which computers have been put to work is in jet-engine design. Part of this program involves the evaluation of one jet-engine design against another, which means a study of performance over a range of flight speeds and altitudes ranging up to Mach 3 and 85 000 feet. It also involves the matching of engine to airplane over this range. In terms of individual calculations, this adds up to a lot of figuring. A hand calculation of one performance point for a turbojet takes at least two hours. When you need 2500 performance points, you're talking about a large quota of man hours.

At present a vast amount of computer programming has been accomplished; this has already been used in some calculations, and can be applied in later design calculations as well.

Power System Engineering—A related problem to the design of products is the design of systems. Westinghouse has long been active in this phase of engineering design with the a-c calculator and the analog computer. Today, the tremendously fast, powerful calculators such as the IBM 704 make many new system-engineering problems applicable for digital computers. Consequently, several computer programs for augmenting the a-c calculator board services have been completed, and several others are planned. For example, programs have been completed and used for determining economic dispatch of power generation in a system. Furthermore, alternate plans for expanding a power system can be evaluated from the standpoint of operating costs, so that the most advantageous pattern for growth can be quickly determined. A few of the other power-system problems that have already been programmed are load-flow studies, short-circuit studies, and system-stability studies. These programs and the digital-computer facilities will be added to the a-c calculating board and other services already serving electric-utility engineers ■

Two modern high-speed digital computers, IBM 704 (left) and UNIVAC (right) in use at the East Pittsburgh plant.



Seeking perfection in alloys they develop, metallurgists dislike the tiny foreign bodies, called inclusions, that show up along grain boundaries or within a crystal itself. The source of these impurities or inclusions has been difficult to track down. The size of the inclusion has been partly responsible since some of the smallest run between three and five mils in diameter. Using a commercially available instrument with a power-operated drill only one mil in diameter, metallurgists are now able to remove samples of the inclusion for analysis on their emission spectrograph. If the inclusion is large enough and not too hard, the tiny microdrill can be driven directly into the material and the cuttings used for analysis. But if the inclusion is extremely small or intensely hard, then it becomes a matter of drilling a series of holes around the inclusion and actually lifting it out of its surroundings in the base metal.

Injection Molding of Thermosetting Materials

Thermoplastic materials are relatively simple to mold in a continuous cycle by the injection process. Not so with thermosetting plastics. Any continuous supply of material to the mold is limited by the possibility that the material will cure in the system outside the mold—and thus clog the passage leading to it.

A standard injection-molding machine has been modified to permit putty-like thermosetting molding compounds to be molded in a continuous automatic cycle. The molding material is contained in a cylinder in sufficient quantity to mold 25 to 50 pieces before recharging. The end of this cylinder is in contact with the hot mold only during the injection period, and sufficient heat is not transferred to the cylinder to set up the material in the cylinder nozzle.

A typical molding cycle, which is timed to run to completion just as a thermoplastic injection cycle, has the following sequence: The safety door of the press is closed, which depresses a switch to actuate a series of cycle timers. These timers control the length of time for (1) closing the mold, (2) moving the injection cylinder against the mold sprew, (3) injecting material into the mold, (4) dwell time to permit the sprew to cure, (5) retracting the injection cylinder from contact with the hot mold, (6) curing time, in addition to that already used, to complete the cure of the piece, (7) opening of the mold and ejection of the cured piece. The cycle can be repeated by closing the safety door of the press as many times as the capacity of the injection cylinder permits. ■

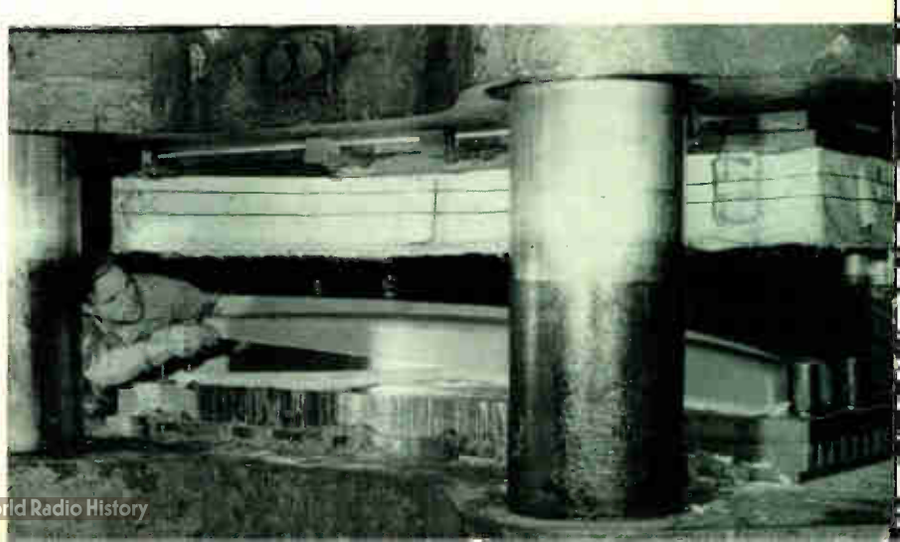
Designing Alloys

For centuries, alloys have been developed by cut-and-try methods. Last year the first steps were taken toward establishing principles that may ultimately enable a metallurgist to *design* alloys to given specifications. The first practical application of this new technique came in the development of a new high-temperature alloy, called Nivco. This is an alloy designed to have high strength at temperatures as high as 1200 degrees F, and with the ability to resist mechanical vibration. The alloy was developed primarily for steam-turbine application, to meet future needs for better blade materials.

Present turbine-blade materials, such as 12-percent chrome steel, have excellent overall properties up to about 1050 degrees F initial temperature. Above that temperature they must be used at lower stress levels. The new alloy promises to solve this problem. At 1200 degrees F, Nivco has five times the strength of 12-percent chrome steel, and a damping nearly equal to chrome steel at 900 degrees.

The new alloy is composed principally of cobalt and nickel, but includes smaller amounts of five additional elements. The ultimate tensile strength of the metal is about 100 000 pounds per square inch at 1200 degrees F. Nivco is prepared by melting in a vacuum furnace under an inert atmosphere of argon gas. After melting, it is treated and forged at 2000 degrees F.

The day when all alloys can be designed in advance to meet given specifications is still many years away, but the first steps have been taken in that direction. ■

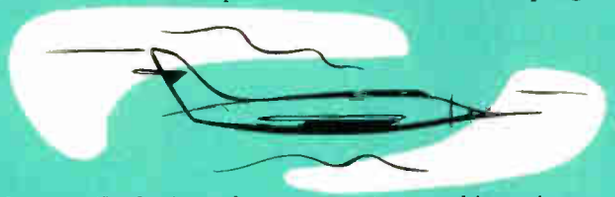


Corrosion, breakage, and need for maintenance have been all but eliminated with the development of a new fiber glass reinforced fluorescent streetlighting fixture. The housing is 6 feet long, 2½ feet wide, and has about a 10 inch draw at its deepest point. The new housing represents the first application of reinforced plastics in outdoor lighting equipment.

On the bottom half of an extremely complicated mold, four layers of glass mat containing the proper color pigmentation are laid down. Poured over this is a general purpose styrene modified polyester resin having a high degree of moisture and sunlight resistance. The 600-ton press is closed and the housing is formed. The new housing has a "molded-in" aluminum color.

■ The familiar electric coupling is playing a new role in an experimental program by the Maritime Administration. The program's object is to explore different means of increasing the speeds of the familiar Liberty ships of World War II. The speed of most of the vessels is about ten knots. Using a redesigned bow, and several different propulsion methods on different ships, the speeds have been raised to 17 or 18 knots.

One propulsion method replaces the usual 2500-hp steam reciprocating drive with two 3125-hp, 260-rpm diesel engines. These are connected to the gear-pinion shaft through Westinghouse electric couplings. Advantages of this electric coupling include the fact that vibration is not transmitted from the engines to the gearing or propeller shaft; also, the power to the propeller can be instantly disconnected or connected—an advantage in maneuvering—merely by de-energizing the d-c field of the coupling. ■



■ Electronic equipment has become the brain and nerve center for modern high-speed aircraft. A single "crossed wire" in this complex nervous system could result in loss of both pilot and airplane. Therefore, every effort must be made to insure correct wiring with components of proper value. But individual testing and checking of complex electronic equipment is extremely time consuming. To save on the time required, and to eliminate possible human errors, automatic test machinery is now employed. Using this equipment, the operator need merely push a button, and the automatic tester takes over. If there is a wiring error, or a faulty component, the tester automatically stops, and a counter that has been counting each test identifies the trouble. Also, the test equipment is foolproof, in that if an operator connects it incorrectly, those tests affected by the incorrect connections would automatically be rejected. ■

■ A special turntable is being developed for field testing the gyroscopes used in airplanes aboard aircraft carriers. Periodically, the fire-control gyros must be removed from the aircraft and checked for accuracy.

The table is gyroscopically controlled so that it is held independent of ship action. The gyroscopes to be tested are then mounted on the turntable. When the table is turned at a known rate and direction, the output of the gyroscope being tested can be checked. Maximum error in measurement is 1/170 of a degree per second. Single-degree-of-freedom gyroscopes of both rate and integrating types can be checked. ■

■ A mile-long, extra-high-voltage electric transmission test line, located 10 300 feet above sea level, will be constructed by the Public Service Company of Colorado at its Leadville Substation. Object of the test line: to determine operating conditions, including corona losses and radio influence, at high altitudes. Data will be compared with that already obtained at low altitudes, so that suitable designs for high-voltage lines at altitudes from 5000 to 12 000 feet can be developed. ■

■ Before being formed into valves for automobile engines, the piece resembles an "onion"—a stem with a blob of metal at one end, which will be formed into the valve head. Induction heating has been used to produce in-line heating for continuous production rates. The work-handling equipment is a rotating table with mechanical fingers that pick up the valve onion, and carry it through the work coil, heating the head to 2100 degrees F. The onion is then ejected and picked up by subsequent automatic equipment that carries it to a forge for forming the valve head. The heating step was developed to bridge the gap between the free-forming operation where the "onion head" is formed, and the forging of the onion into the valve. The free-forming operation is a slow process, whereas the forging operation is fast; faster in-line production has therefore been accomplished by taking production "onions" from several forming machines, reheating with the automatic equipment described, and feeding into the forge. ■

■ An indicating light designed to solve one problem wound up serving a dual role. Initially it was designed as a push-to-test indicating light, to light up when a motor is on or off. When an operator, for example, presses a push-button to start a motor and the indicating light does not come on, he is left in a quandary as to whether the bulb is burned out or whether circuit trouble exists. Either takes time to investigate. By merely pressing on the lens of this unit he can test the bulb to see if it is burned out. Because it serves the purpose so well, however, this unit is also being used as a combination pushbutton and indicating light. ■

■ A new clinical medical device for making motion pictures of a fluoroscopic image while simultaneously viewing the same image will make fluoroscopic examinations easier on both patient and doctor. By recording the fluoroscopic image on 16-mm motion picture film, dynamic records can be made that can be examined over and over again. The patient's progress between fluoroscopic examinations can be easily determined.

The Cine Fluorex unit consists of a motor-driven motion-picture camera mounted on a fluoroscopic image intensifier, which electronically brightens the fluoroscopic image to a level that can be photographed, while keeping the x-ray dosage to the patient at a low level. Though the concept of x-ray movies is not new, it could not be practiced routinely earlier, because of the high x-ray dosage necessary. ■

U.S.S. FORRESTAL

59

This is the CVA-59—better known as the U.S.S. *Forrestal*—the Navy's newest aircraft carrier. Other than the fact that this is the most powerful fighting ship afloat and probably the fastest, many other superlatives apply. For example, the platforms of the deck-edge elevators weigh 166 tons each and measure 52 by 62 feet, yet they transfer 70 000-pound jet planes from hanger deck to flight deck in a matter of seconds. The 59 000-ton, 1039-foot carrier is driven by Westinghouse propulsion turbines of "more than 200 000 horsepower" at speeds up to "about 40 land miles an hour", according to Navy sources. (Official United States Navy photographs.)