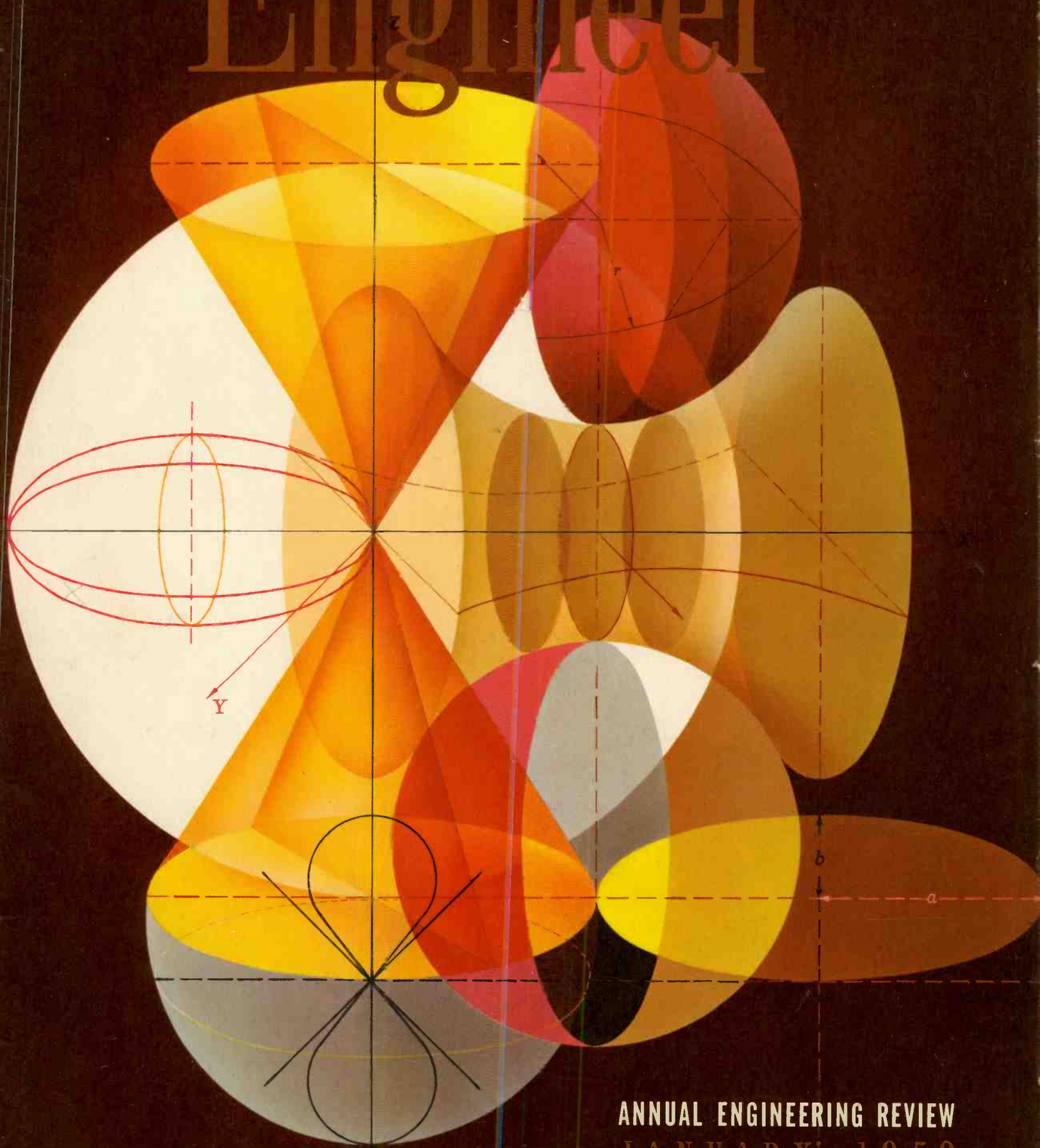
WESTINGHOUSE

Engineer



ANNUAL ENGINEERING REVIEW

JANUARY 1959

BALANCE SHEET FOR ENGINEERING - 1958

Once a year, businessmen total their assets and liabilities, and prepare a final balance. This determines financial success, and suggests avenues of improvement for the coming year.

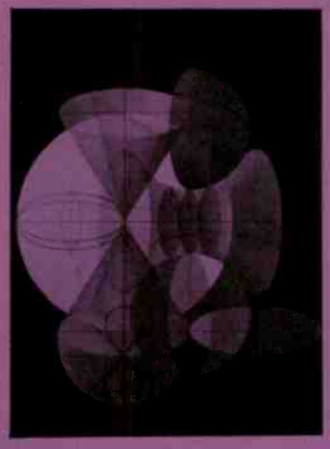
One of the largest assets of an engineering and manufacturing company like Westinghouse is *engineering and scientific know-how*. This entry cannot show up on the financial statement per se, but its effects are evident. Engineering accomplishment is a vital necessity—in fact, the backbone of financial success—in companies with such a large stake in industrial and military progress. Why? The increasing complexity of modern civilization demands a continuing and increasing pace in technological development; the world situation, man's realization of the earth's declining fuel resources, the constant struggle for a better standard of living—these are but a few of the factors that spur advancement.

Significantly, results of these three motivations can be illustrated with a single example—Shippingport, the first large-scale nuclear-fueled power generating station, which was dedicated early in 1958. Tremendous technological progress was made during World War II on nuclear fission, and this knowledge has been applied to useful, peacetime purposes in the period following the war. Thus, nuclear energy will stretch energy reserves many times—which certainly contributes to improvement of our future standard of living. Many other examples, perhaps less spectacular, but nonetheless essential to the overall picture, could be drawn.

This Annual Review is our "entry" of scientific and engineering accomplishment for the preceding year. True, it is not complete—space does not permit—but it is representative of the technological problems being attacked and solved. They range from nuclear science, man's newest knowledge, to improvements in such ancient arts as metal working.

Scientists and engineers, like businessmen, will pause briefly to review their accomplishments, plot their future, and then resume their efforts to make each year's balance sheet better than the last.

J. A. HUTCHESON
Vice President



COVER DESIGN: Mathematics is the backbone of modern research and engineering accomplishment—hence an appropriate subject for the issue devoted to the year's engineering accomplishments. This month's cover design by the R. G. Marsh Associates is an artistic pattern of geometric shapes.

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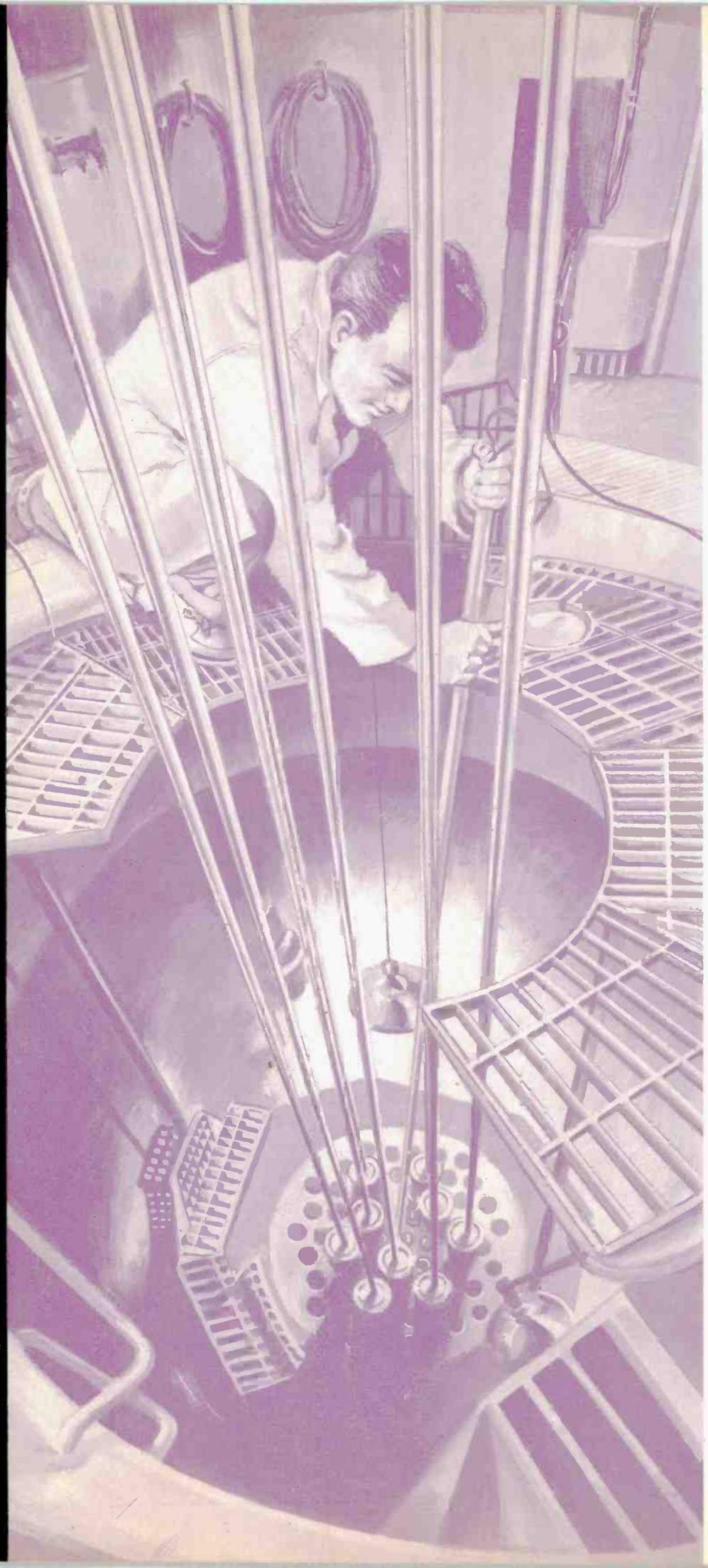
ANNUAL ENGINEERING REVIEW

of the year 1958



The dedication of the Shippingport Atomic Power Station and the launching of the USS *Skipjack* on the same day—May 26, 1958—are symbolic of progress in nuclear power for both peacetime uses and defense purposes. The PWR plant at Shippingport is the United States' first full-scale central station atomic power plant devoted exclusively for civilian use; the *Skipjack* is the first of a class of high-speed, high-performance attack-type nuclear-powered submarines now scheduled for construction by the Navy.

These milestones in nuclear progress are separate achievements; however, they are also mutually dependent. Both are built around nuclear power plants of the pressurized-water type. ■

the naval reactor program

Submarines—Nuclear submarines continue to set new records. Probably the most spectacular feat during 1958 was the submerged run of the *Nautilus* over the North Pole. A few days later the *Skate* duplicated the feat, while gathering substantial amounts of scientific information during a more extensive exploration of the polar region.

On her shakedown cruise, the *Skate* established an east-to-west speed record of 8½ days for a submerged Atlantic crossing. On August 25, the Navy announced that the *Nautilus* had bettered the Atlantic crossing record of the *Skate* by two days.

While these record-breaking feats were taking place, more nuclear submarines were being readied. Two new nuclear submarines of the fleet reactor type—the *Sargo* and the *Swordfish*—went to sea, while a fourth, the *Sea Dragon*, was launched. The Navy's second atomic submarine, the *Seawolf*, will be refitted with a *Nautilus* type pressurized-water reactor plant.

The *Skipjack* slid down the ways at Groton, Connecticut on May 26, 1958—the first of a class of ships with underwater characteristics superior to the *Nautilus* and other previously constructed submarines. The *Skipjack* will be the first marriage of nuclear power to the advanced hull form developed with the *Albacore* (SS569), a diesel battery powered development submarine.

Currently, Westinghouse is working on power plants for 20 additional nuclear submarines that will go to sea in the next few years. The nuclear Navy is taking shape.

Submarine Prototype—S1W, the prototype plant for the *Nautilus*, built at the National Reactor Testing Station in

Idaho, has produced much valuable information since it first went critical on March 30, 1953. Tests made on the second loading of nuclear fuel confirmed many theoretical and experimental predictions. During 1958, the second core was removed. Many subassemblies were examined, and a program of testing was initiated for this expended core, including detailed investigations into the core's metallurgical, chemical, physical, and mechanical conditions.

On March 31, 1958, the third core was installed. The third-core test program encompasses the areas of design verification, limited proof testing of special subassemblies, and extended thermal-hydraulic studies. A prime objective will be the correlation of nuclear analyses and experimental data.

Surface Ships—The first of the two nuclear reactors of the land-based prototype power plant for large naval surface ships achieved criticality October 21, 1958. Eight such reactors will power the Navy's first atomic powered aircraft carrier, the USS *Enterprise*. Two reactors of a similar type will also be used to power the Navy's first guided missile firing cruiser, the USS *Long Beach*.

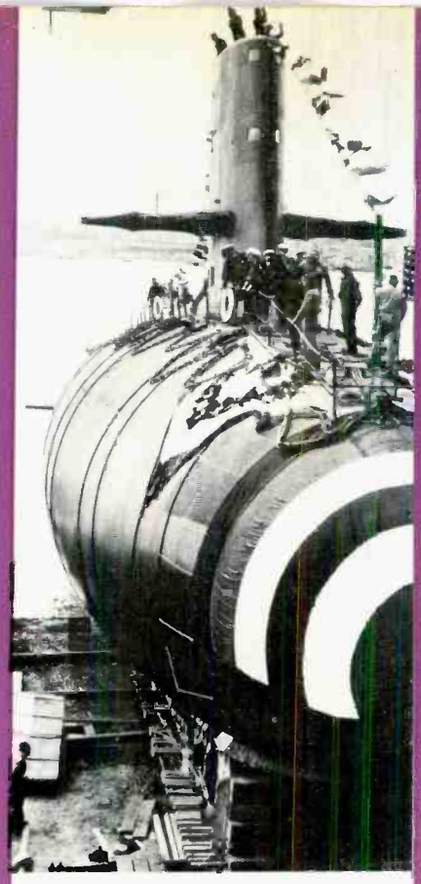
Westinghouse is responsible for the design and development of the reactors for all of the above projects, under the direction of, and in technical cooperation with the Naval Reactors Branch, U.S. Atomic Energy Commission. ■

PWR plant

The Shippingport Atomic Power Station, producing power since late 1957 is demonstrating its capability to operate as an integral part of an electric-utility system with flexibility and reliability of the highest order.

In addition, the plant is serving an equally important role as an operating "laboratory." The test program has already provided invaluable information —information that could not be obtained in any other way.

In general, the emphasis of the current test program is on exploring the performance of a seed and blanket type core and a pressurized-water plant as a function of time, determining capabilities both at steady-state full power conditions and in transient situations. To this end, a series of full-power runs of 1000 hours duration are in progress; spaced between the extended runs are periods of approximately six weeks devoted to testing at conditions other than full power. In mid-August, when the reactor system was shut down after its first 1000-hour test run, the plant had logged a total of nearly 1700 effective full-power hours. In September, the plant started on its second 1000-hour run.



The USS *Skipjack* slides down the ways at Groton, Connecticut. (*Photo from Electric Boat Division, General Dynamics Corporation*)

The *Nautilus* enters New York harbor after her submerged run over the North Pole.

Because of the nature of the test program, the plant has been operated for a considerable time as a peak-load station in the Duquesne Light Company system. It has met these requirements. Load changes at the rate of 3 mw per minute can be made over the entire operating range, and load changes of 3 mw per second can be made for increments of 15 mw.

Particularly impressive has been the simplicity with which this nuclear station can be operated after it is on the line. In manual control, the operator's only regular action is periodic addition of make-up water to the reactor coolant system, and the movement of control rods to maintain average system temperature at the desired value. These two operations require the manipulation of but three control switches located in the control room. Under automatic control, the operator has but to add make-up water, and monitor plant instruments. The reliability and self-regulation of the plant was amply demonstrated when, with the plant operating at 60-mw net output and three coolant loops in service, the turbine throttle valves were tripped by a condition in the secondary system. This meant almost instantaneous loss of load on the reactor. Conventional stations would require considerable adjustment of fuel feed control and the relief valves on the boilers would probably be lifted. In the PWR plant, the operator did not even have to insert the control rods. A pressure and temperature transient was followed for about 10 minutes without control-rod motion; the transients subsided without oscillation or other indication of instability.

Experience to date has shown that some major plant maintenance can be accomplished with the station at full power. Well-trained maintenance forces and proper radiation safety procedures are required.

Of considerable interest to the power reactor field is the power oscillation phenomenon found to exist under certain conditions in the PWR core. The power density in one region of the core will slowly increase while the power in another region slowly decreases at the same rate. The variations are sinusoidal with time and can be observed with normal nuclear instrumentation. The period of the oscillation is about 24 hours. The magnitude can be controlled by slight insertions of control rods in the regions that are increasing in power.

These are but a small sampling of the results obtained thus far from the Shippingport Station. The test program is continuing, and each new test period yields a mass of information that will be of inestimable value to designers of future plants. The station is a joint project of the Atomic Energy Commission and the Duquesne Light Company; the nuclear portion of the plant was designed and developed by Westinghouse under the direction of and in technical cooperation with the Naval Reactors Branch of the AEC. ■

Yankee progress

At Rowe, Massachusetts, the buildings for the 134-mw nuclear power station for Yankee Atomic Electric Company are taking shape. The foundation and all grading is completed, the plant is "under roof," and the steel of the spherical vapor container is being erected.

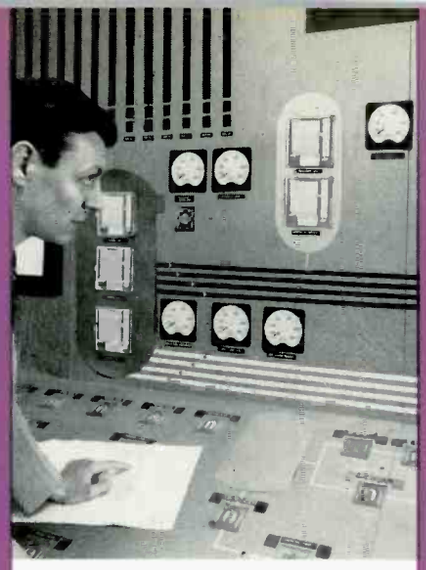
Meanwhile, engineering of the pressurized-water reactor system and construction of components are reaching late stages. All major components except the control-rod drive mechanism and the core are on order. Nuclear components will begin to reach the plant site in mid-1959, with steam generators and pumps scheduled to arrive in late summer, and the reactor vessel in the fall. Initial system testing is scheduled for the spring of 1960, with the plant going critical in late summer. Regular operation of the plant is scheduled for January 1961.

Many innovations are being considered in this plant, most with the aim of simpler construction for pressurized-water plants. For example, the fuel for this reactor consists of uranium-oxide pellets, which are contained in long stainless-steel tubes. For nuclear reasons, these pellets must fit snugly in tubes, and changes in longitudinal spacing should be avoided. One method explored is to place the pellets in the tube, then stretch the tube to close up the space between tube wall and pellet. Another process being investigated is the insertion of spacers between pellets and then stretch forming the tube. This not only assures that clearance space between pellets is evenly distributed along the rod, but also helps distribution of fission gases. ■

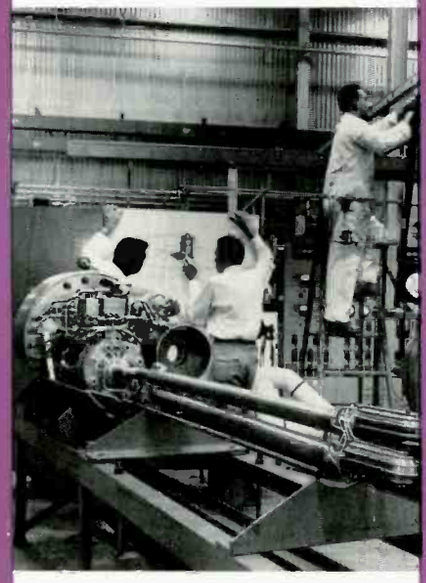
aqueous homogeneous reactor project

The single-region, homogeneous reactor project, while still in Phase I, or the "feasibility" study stage, has moved into a new area, the design and construction of large-scale prototype components.

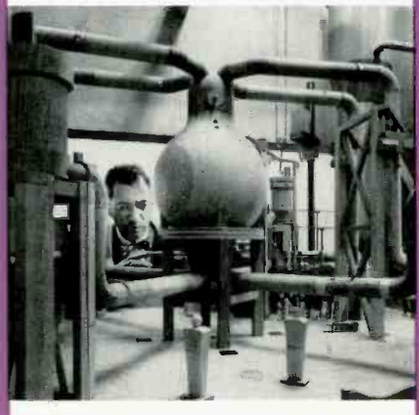
The prototypes serve two important purposes. First of all, they enable engineers to work out the remote maintenance procedures that will be necessary in this plant. Already being tested are remote maintenance procedures for pumps, and remote welding. Procedures such as this require design of jigs and fixtures, as well as planning for actual step-by-step disassembly and assembly.



This is a mockup of the main control console for a large atomic power plant. Engineers are using this mockup to determine arrangement of instruments.



Symbolic of the active research and development program now in progress is this test loop built by Westinghouse for insertion in the Oak Ridge test reactor. Believed to be the first slurry circulating loop for use in a test reactor, this unit will provide important answers in the development of the homogeneous reactor.



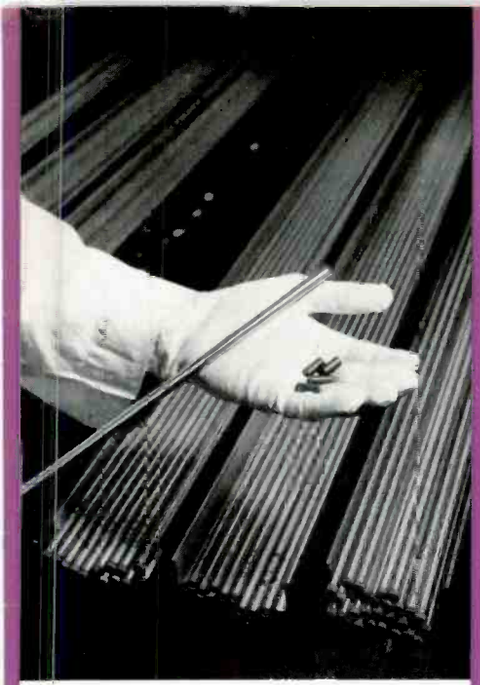
This scale model of a homogeneous reactor plant is used to help PAR designers study methods for remote handling procedures. At center is the reactor, and leading from it are the four primary loops.

The second important purpose of the large-scale prototypes is in studying fluid-flow problems of the slurry-fuel mixture. Loop D, which circulates slurry at the rate of 4000 gpm, has logged close to 2000 hours of high-temperature service. It has yielded considerable information to supplement that obtained in about 30 000 hours of experience in four 200-gpm loops. Several new systems have been added to Loop D, including a high-pressure drain system, a slurry concentration control system, and a high-pressure makeup and letdown system, all prototypes of systems planned for the final plant. During 1959, a reactor vessel model and a steam generator will be added to the loop, so that it will closely resemble the eventual reactor system.

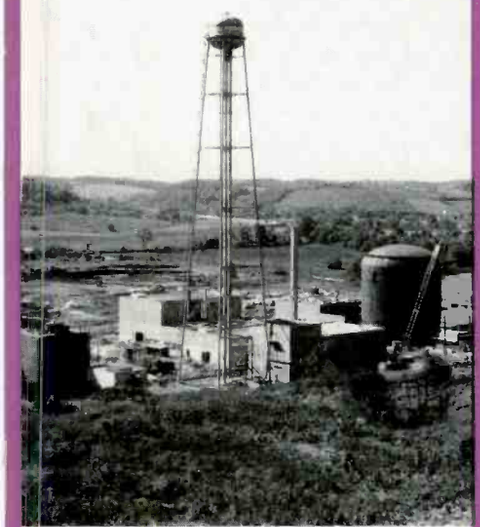
The PAR project, initiated in 1955 as a joint development of Pennsylvania Power and Light Company and Westinghouse, has since seen the Baltimore Gas & Electric Company join the project group. Recently, Congress has approved the basis of a contract under which the AEC would support research and development programs for the years 1958-1959. The study phase of the project is now expected to end in January 1960, after which the decision as to the construction of the plant will be made. ■

Carolinas Virginia project

A new proposal, approved by the Joint Congressional Committee on Atomic Energy in May, involves a substantially different approach to a pressurized-water reactor. Instead of one large pressure vessel to contain the coolant, moderator, and fuel elements, the reactor will, in a sense, be broken into separate pressure elements. The idea, in general, is this: fuel elements will be contained in pressure tubes of about 3.5 inches in diameter. As presently contemplated, heavy water at 1500 psia will flow through these tubes and act as the coolant. The moderator will also be heavy water, but will flow *outside* the pressure tubes and play no part as a coolant. The moderator will be maintained at slightly above atmospheric pressure. One obvious advantage of this design is the elimination of a large, heavy-walled pressure vessel. Small tubes to withstand the same pressures are simpler and less expensive to build.



Belgian Reactor—The Belgian reactor plant, being constructed for the Bureau d'Etudes Nucleaire, moved into its late stages in 1958. Of the major plant components, the steam generator, was shipped in August, and turbines and pumps were expected to be shipped before the end of the year. The reactor core is scheduled for shipment in late 1959, so that operation of the plant can begin later in 1959 or early in 1960. Photo shows fuel pellets and rods.



When scientists and engineers first started working on nuclear power plant designs, they were faced with many unknowns—but among the largest was the effect that radiation would have on materials. Much has been learned since that time, but a tremendous amount of work remains. Toward this end, the Westinghouse Testing Reactor has been constructed. The WTR is scheduled for completion early in 1959, and for operation in May.

Facilities of this plant will be available to industry for testing purposes. Also 3000 cubic inches of irradiation space will be reserved for the exclusive use of colleges and universities. This will be available free of charge to any research or study program completely financed by a college or university.

The objective of this project, initiated in 1957 by Westinghouse and the Carolinas Virginia Nuclear Power Associates, Inc., is to design and construct a nuclear plant that will produce the steam needed to develop 19 000 kw of electricity. This steam will be fed into an existing steam header at the South Carolina Electric and Gas Station at Parr Shoals. The program is in three phases: research and development, construction, and a post-construction research and development period of several years. The nuclear plant is scheduled for completion in 1962, and is intended as a prototype for an eventual 200 000-kw or larger station. ■

reactor design uses "floating" fuel

The vast majority of nuclear power plants built to date have used movable control rods and fuel elements that were fixed in position. A different concept, now being studied by Westinghouse for the City of Burlington, Vermont, uses small fuel pellets that are loose, within limits, within the reactor. No control rods—at least in the usual sense—are needed. The technical name for this reactor—the organic moderated fluid bed reactor.

The fuel pellets for this reactor lie in a large cylindrical container, open at the top, and with fluid flow holes in the bottom. The fluid—a hydrocarbon oil—enters the reactor vessel near the top of the fuel container, flows down through the annulus between vessel and container, and up through the container.

Before startup, the fuel pellets rest in a settled, packed bed. By proper choice of fuel enrichment and pellet size, no chain reaction would occur in this condition because of the close spacing of the pellets; or, to put it another way, no moderation takes place, because of the lack of sufficient moderator fluid between pellets. To start the reaction, fluid flow is increased. The flow lifts the particles and disperses them uniformly through the fluid, thus providing a moderation medium between pellets. Thus fast neutrons can be slowed to thermal speed by the moderator, so that a chain reaction can be sustained. Increase of fluid flow increases the chain reaction, i.e., produces more heat—up to a point. After the bed expands beyond a predetermined point the neutron absorption of the hydrogen in the fluid exceeds the moderation effects, and the reactivity and heat output decrease with further expansion.

In the reference design, a heat output of 120 mw is proposed. The organic coolant, circulated by main coolant pumps, enters the reactor at 574 degrees F and leaves at 680 degrees.

Several points about this type of reactor are worth noting. For one thing, the fuel burnup in such a system would be essentially uniform, and the ratio of maximum to average burnup will be essentially unity. Because of the initial high conversion ratio, an extremely long criticality lifetime results. This means that the limitation on fuel lifetime is based on mechanical and physical considerations rather than on nuclear design. While this reactor design is still in the conceptual stage, it holds promise for economic power production. ■

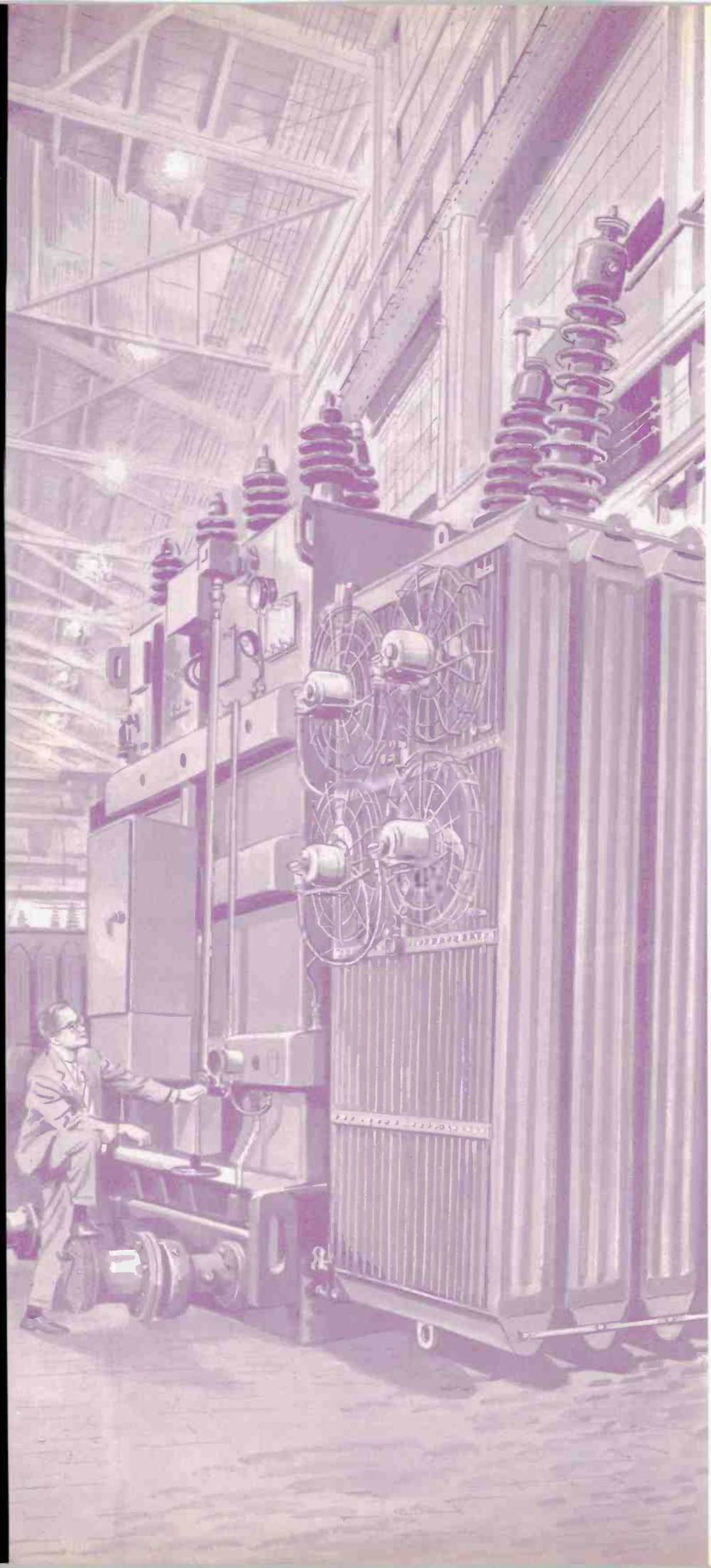
detectaire—a liquid level device

The proper function of a canned motor pump in either a pressurized-water reactor or a forced-circulation boiler application depends upon the pump being solidly filled with water. However, since the rotor cavity forms a high spot in the system, entrapped gases that may be in the water tend to migrate up into the rotor cavity. When this occurs, the internal circulation in the pump is interrupted, thus starving the bearings of their cooling and lubricating water. To assure proper operation of the pump, some means must be available of detecting gas at the top of the hermetically sealed 2000-psi system.

A new device, called Detectaire, fills this need. It consists of a small chamber attached to the top-most point in the pump and into which the gas can migrate. In this chamber are two thermocouple wells and a heater well, with one of the thermocouple wells and the heat well being connected together at their lower extremity by a small metal bridge.

The function of the device depends upon the difference in thermal conductivity between liquid and gas. When the chamber is filled with liquid, because of the good thermal conductivity the heater well and thermocouple wells all maintain a uniform temperature, and thus the output voltage of the two thermocouples are identical. By connecting the two thermocouples differentially opposing, there is no net output voltage. However, when the chamber is filled with gas, the bridge between the heater well and the one thermocouple well causes this thermocouple to produce a higher voltage than the thermocouple in the other well. In this case, there is a net output voltage.

Hooking the thermocouples in a differential manner makes the device independent of the ambient temperature and responsive only to the difference in thermal conductivity of the gas and liquid. The net output voltage can be used to actuate alarm signals and lights, and/or to take corrective action if desirable. ■



TURBINES AND GENERATORS

At the beginning of 1958, some 87 million kw of potential unused water power was estimated for the United States. The largest single bite out of this reserve will be taken by thirteen 167 000-kva generators now in preliminary construction stages for the New York State Power Authority's *Niagara Power project*. The first machine is scheduled for delivery in mid-1959. The huge project was made possible by a 1950 treaty between the U.S. and Canada, which basically provides: the normal flow in the Niagara River is about 270 000 cfs; 100 000 cfs must flow over the falls during the daylight hours in the tourist season, and 50 000 cfs must flow during winter and night periods; all water in excess is divided between the U.S. and Canada for power purposes.

To take full advantage of the water allocated to the U.S., the New York State Power Authority will store water, during excess-water periods, in a reservoir with storage capacity of some 60 000 acre feet. Water will be drawn from this artificial lake during daylight hours.

The 167 000-kva generators are 120-rpm machines, operating at 90 percent power factor. The machines are of umbrella-type construction (thrust and guide bearing below the rotor), and the stator frame is 40 feet in diameter.

The initial phase of the *Chief Joseph Powerhouse* was completed last year with the installation of sixteen 67 368-kva 100-rpm waterwheel generators. Space has been provided for extension of the powerhouse to include an additional 11 units in the future.

Two 75 000-kva vertical waterwheel generators, operated at 400 rpm, have been installed in the *Haas Powerhouse* of the Pacific Gas and Electric Company system. This is an unusually high speed for such large machines. This is brought about by an operating head of more than 2300 feet. Water to drive the turbines is brought through a six-mile tunnel and a 4600-foot penstock. The plant is the only major underground station in the United States, and is located 2000 feet back in a granite mountain and 500 feet below the surface. It was placed underground for reasons of economy. The generators will be of two-bearing type construction. They will be driven by vertical-shaft multi-jet impulse-type waterwheels.

On the nearby San Joaquin River about 50 miles northeast of Fresno, two 66 000-kva waterwheel generators will be installed at the Southern California Edison Company's *Mammoth Pool sta-*

tion. The generators and other electrical and mechanical apparatus will be controlled remotely by microwave from another of the utility's Big Creek powerhouses. Mammoth Pool will be the first large outdoor hydro-electric plant on the Southern California Edison system.

At the Idaho Power Company's *Hells Canyon development* on the Snake River, four 100 111-kva waterwheel machines at the Brownlee Dam were put on the line in 1958. These are outdoor units and will operate at 128 rpm, 90 percent power factor. Four more 52 778-kva machines will be installed in 1959–1960 at the Oxbow Dam, which is a few miles down the river from the Brownlee Dam.

On the Columbia River, seven 107 000-kva waterwheel generators are scheduled for installation on the *Rocky Reach Site* of the Public Utility District No. 1 of Chelan County, Washington. The machines will operate at 90 rpm with a head less than 100 feet. Because of the slow speed but large rating, the machines will be approximately the same physical size as the Niagara machines.

The 20 generators for the Rocky Reach and Niagara sites will be the largest machines, both physically and electrically, that have been built by Westinghouse. ■

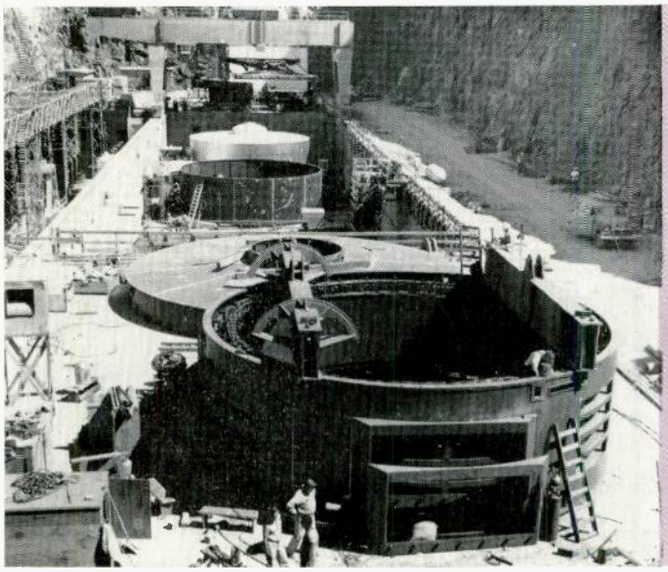
improvements in Mag-A-Stat regulator

Three major improvements have been made in the type WMA Mag-A-Stat, the voltage regulator and excitation system for turbo and waterwheel generators: First, the equipment has been redesigned in "building-block" form. This facilitates testing, components are more accessible, and individual panels are available for multiple applications. Secondly, a new and improved excitation limiter circuit is used. A greater range of settings is provided, and theory and operation is simplified. Settings can be made easily and directly from "per-unit" quantities. The greater range was desirable because modern practice permits generator operation well into the under-excited region; stable machine operation is possible below steady-state pull-out values with proper regulator operation. The limit setting is the same ideal circular kva characteristic, purposely made to follow the steady-state pull-out characteristic of the machine. Third, regulator control circuitry has been improved. Basically, the major change involves a transition from a "stay-put" to a "spring-return" control switch. Spring-return switches control circuit breakers that switch the incoming a-c power to the regulator, and switch the d-c output power from the regulator to the exciter control fields. ■

turbine improvements

Each year, increased turbine ratings with higher steam conditions are announced. But to make these increases possible, a multitude of turbine design detail improvements are required.

Shrink Fitting Discs Scientifically—When turbine discs are shrunk on a shaft, the shaft elongates. The cumulative elongation resulting from shrinking six discs on the turbine shaft can total as much as 1/16 inch. This is a sizable figure when turbines are being built to accuracies of thousandths of an inch, and in the past, this elongation was compensated by accurate machining of the shaft after each disc was shrunk in place. By accurately precalculating this elongation, turbine designers have considerably simplified this assembly procedure.



At the Idaho Power Company's Hells Canyon development on the Snake River, three of the four 100 111-kva waterwheel generators at Brownlee Dam are shown during construction.

Reducing Thermal Stress in Cylinder Walls—With conventional high-pressure steam inlet conditions of 2400 psi, 1050 degrees F, the temperature drop between the inner and outer cylinder walls should be kept to a minimum to reduce thermal gradient stresses and possible resultant distortion of the inner wall. In the past, steam was passed through the entire blade path, then between the inner and outer cylinders, and finally exhausted. Turbine designers have found that by redesigning the element so that the steam first runs through two-thirds of the blading, then between the inner and outer cylinder walls, and back through the last third of the blading, a lower temperature difference results across the inner cylinder wall. A reduction of balance piston diameters is obtained at the same time, as blading thrusts are balanced, so that a better overall leakage efficiency is also obtained. This new design will be used on high-pressure elements for a wide range of turbine ratings from 170 to 325 mw.

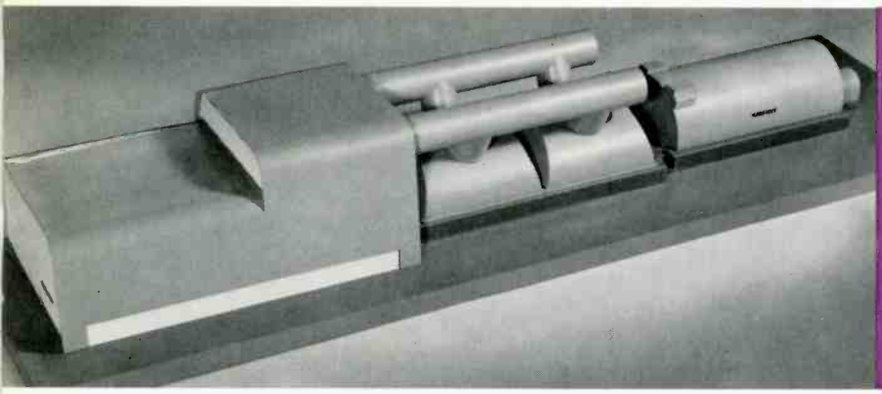
Fabricated Low-Pressure Blade Ring—By 1960, almost all Westinghouse 3600-rpm turbines will have fabricated low-pressure blade rings, replacing the cast blade rings presently in use. This will provide a ring consisting of more homogeneous material, since the steel plate that makes up the fabrication has had considerable working during the rolling process, and voids and porosity are thereby reduced. Stress relief can also be more effective since less metal will be removed after annealing. And last but not least, the fabricated structure can be made in less time and more economically. ■

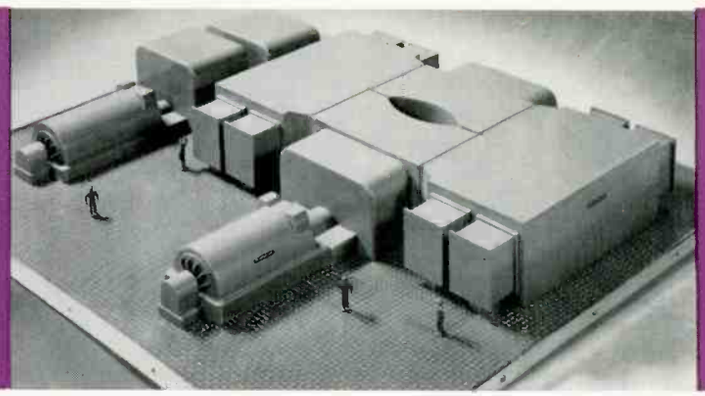
more kilowatts on a single shaft

A new champion is being groomed for the title of "largest" in the tandem-compound 3600-rpm turbine class. The turbine will have a rating of 325 megawatts with initial steam conditions of 2000 psig, 1000 degrees F, with reheat to 1000 degrees F, and 1½ inches hg absolute exhaust back pressure; it will require a maximum of over two million pounds of steam per hour. This will be the first tandem-compound machine with four exhausts, previous four-exhaust units having been of the cross-compound type. It will be the longest unit ever designed; overall length, including generator, is about 126 feet.

The inner-cooled generator driven by the turbine will be rated at 384 mva, 0.85 power factor.

The turbine-generator unit is scheduled for shipment to the Helena, Arkansas station of the Arkansas Power and Light Company in 1960.





Tandem-Compound For Nuclear Service—Turbines designed for use with nuclear power plants to date have operated with saturated steam at relatively low temperature; an exception to this is the 250-mw, 1800-rpm turbine being built for the Indian Point Station of the Consolidated Edison Company of New York. This unit will operate with separately-fired superheater. Inlet steam conditions to the turbine are 355 psig, 1000 degrees F, and 1 inch hg absolute exhaust pressure. In general, the characteristics of this turbine are similar to those of the intermediate- and low-pressure elements of large conventional cross-compound reheat turbines. Because of the large volumetric flow to the turbine exhaust, two rows of 44-inch exhaust blades are used. This will be the largest tandem-compound 1800-rpm turbine Westinghouse has built. ■

steel for super pressure

The super-critical pressure turbine element being built for the Cleveland Electric Illuminating Company is unique in one respect. The super-pressure element will be constructed from a ferritic rather than an austenitic steel alloy because of this customer's desire to utilize all-ferritic materials for turbine parts. Steam inlet conditions of 3500 psig at 1100 degrees F with reheating at 1050 degrees F were selected after studies indicated this combination to be a practical one for ferritic materials. The super-pressure element is similar to that of the Philadelphia Electric Company's Eddystone unit. The other turbine elements are similar to a conventional tandem-compound, triple-exhaust, single-shaft machine. ■

TRANSFORMERS

The limiting factor on the life of oil-filled transformers, particularly at above-normal temperatures, has been the deterioration of insulating paper. Gradually it loses its strength and becomes brittle. A new insulating system changes all this. By adding an organic stabilizing compound that reacts chemically with the cellulose fibers of the paper, the paper is made stronger and longer lasting.

Development of the new insulation system had several immediate results. In distribution transformers, where it was initially applied, the system permitted breaker trip settings for CSP units to be raised; the new settings boost normal overload capacity by about 25 percent over 1954 settings, and an additional 15 percent is available on an emergency overload basis.

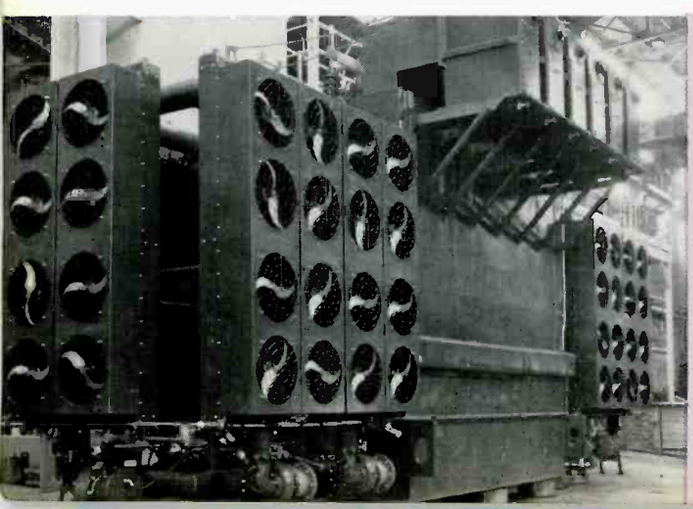
Thus a 25-kva unit with 1954 settings, assuming 75 percent preload and 35 degree C ambient, would trip off the line in 90 minutes when carrying about 47 kva. Equipped with the Insuldur system a 25-kva transformer, for the same period of time, would carry about 60 kva. Or, if the load is kept constant at the initial value of 47 kva, the trip time is increased from 90 minutes to 3¼ hours.

In addition to fewer breaker trip-outs and more emergency capacity, utilities will have greater flexibility in scheduling change-outs. While the breaker trip setting will be raised, the setting at which the overload signal light operates will remain the same. With this increased band width between overload signal and trip operation, a greater time can elapse before change-outs are necessary in areas where load is growing.

The Insuldur system was also adopted this year for oil-filled substation and power transformers. In this case, it permits power transformers to operate at 10 percent higher overloads without additional loss of life. The system is not a means of increasing name-plate rating, since current-carrying parts have been designed for that rating. However, it does offer a means of obtaining overload when economically justified. ■

inner cooling for transformers

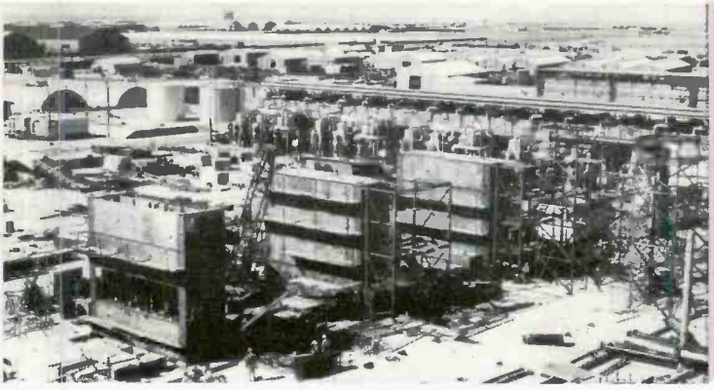
With power transformers continuing to grow in rating, a new technique called "inner cooling" provides a major assist to transformer engineers. In this design oil is circulated between the strands of parallel conductors at the same potential —rather than through oil ducts between coils and windings. The new method allows use of materials with higher insula-



Left—Power transformers continued their phenomenal rise in rating, the record this year being chalked up by a 380-mva generator transformer delivered to Commonwealth Edison Company early in 1958. But more interesting than the size of its rating is that this unit provides greater capacity in less space than any other ever built. This transformer is lighter, lower, and narrower than similar units with only 80 percent as much capacity. The 554 000-pound unit was shipped in a single piece (without high-voltage bushings and cooling equipment) on a conventional depressed center car.

Center—This 7500-kva vapor cooled transformer was installed in mid-1958.

Right—Engineers are continuing to pack more kva into pole-mounted transformers. The newest version is a 250-kva unit only a little larger than the 167-kva transformer, previously the largest unit manufactured. The new unit weighs only 1700 pounds or about 300 pounds more than the 167-kva unit. As a gauge to the accomplishment wrapped up in the above words, the new 250-kva transformer weighs about 600 pounds *less* than the 167-kva unit that was common but three years ago; and it weighs a good 800 pounds less than the previous 250-kva substation unit.



Left—Model of 325-mw single-shaft, tandem-compound quadruple-flow turbine.

Center—An unusual turbine-condenser arrangement in a power plant is illustrated by this model. Basement space limitations in an existing plant made it desirable that the condensers be located on the turbine operating floor level. Instead of exhausting steam to the condenser in the conventional manner from the bottom of the turbine casing, the steam exhausts through two openings in the turbine casing located above the horizontal joint and on both sides of the longitudinal centerline of the unit. Engineers used a plastic model to determine the optimum arrangement of structural members in the low-pressure turbine casing. The unit is for installation in the Crawford Avenue Station of the Commonwealth Edison Company.

Right—Four-stage flash evaporators shown during installation in Kuwait, Arabia. Four of these units are producing over 2½ million gallons of pure water per day.

tion strength than oil at points of voltage stress. The net effect is that units can be built smaller, lighter, and with higher capacity, with the same design margins as units with conventional construction.

The first transformer of this design was a three-phase substation unit rated 30/40/50 mva, 115 kv, built for New York State Electric and Gas Co. Low voltage is 34.5 kv and the transformer is in the 550-kv BIL insulation class. Three other inner-cooled transformers were scheduled for shipment in 1958, including a 125 000-kva autotransformer. ■

design for convenience

Improving a basically good design usually involves improvement of details —seemingly small changes that nonetheless add up to significant net results. Such has happened to the standard line of power transformers for the 750- to 10 000-kva range, up to 69 kv.

The first thing engineers did was change the way the transformer is placed in the tank. The core and coils are now bolted to the base plate. Then the tank is lowered over the unit and welded to the base plate. The transformer would be untanked in the reverse manner, which means less unloading weight, because the tank is lifted off the transformer, rather than vice versa. Also, less headroom is needed for untanking.

While they were about it, engineers also took a critical look at the instruments that have traditionally been scattered all over the side of the transformers. In the new unit they are all located in a compact instrument center, which makes them easily accessible for reading, as well as lending a neater appearance to the unit. Room for added control is allowed in the instrument center. ■

vapor cooling

In mid-1957, the first vapor-cooled transformer, a 500-kva network unit, went into operation on the Consolidated Edison Company System of New York. In mid-1958, after almost a year's service, the transformer was removed from the line and returned to Westinghouse for examination, after which it will be returned to service.

For a "first of its kind," the unit had performed admirably. No major difficulties were encountered, and most important, operational tests verified the calculated performance.

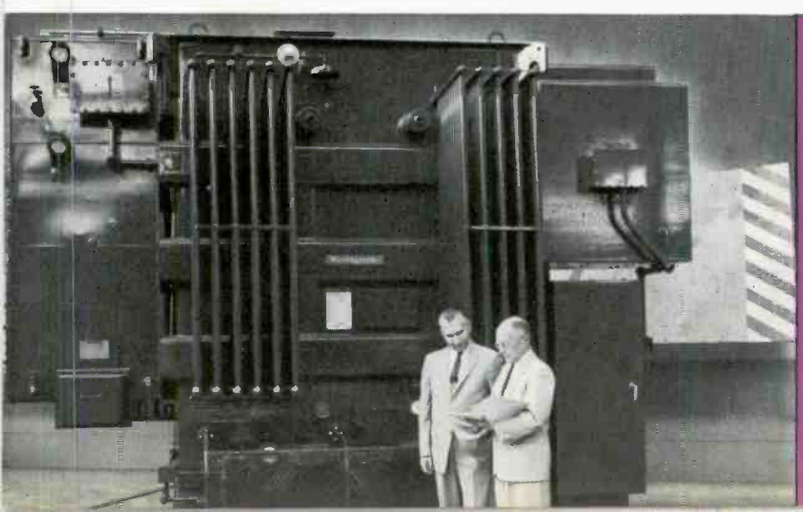
Since the advantages of vapor-cooled units increase with size, the next logical step was a power transformer—and it was not long in coming. In July 1958, a 7500-kva, 34.5-kv, vapor-cooled unit, with 200-kv BIL, was installed on the system of the Baltimore Gas and Electric Company. Like its predecessor, this unit contains a mixture of sulfur-hexafluoride gas and fluorocarbon vapor, which serve as both insulating medium and cooling agent. The vaporizable liquid is pumped from a sump at the bottom of the tank and flowed over the coil and winding. Here it absorbs heat, evaporates, then condenses on the tank and cooler surfaces, and returns to the bottom of the tank as a liquid. The cycle then repeats. The sole purpose of the SF_6 is to maintain dielectric strength until the transformer reaches operating temperature and pressure. At operating pressures, the fluorocarbon vapor has nearly twice the dielectric strength of SF_6.

The new 7500-kva vapor-cooled power transformer requires no fan cooling up to rated load, and will carry 10 000 kva using external fan coolers. The unit is approximately the same size as a conventional oil-immersed transformer.

The prime advantage of gas insulation is safety. The vapor-gas mixture is nonflammable and nontoxic, and thus a vapor-cooled transformer requires no expensive precautions regardless of where it is located. ■

better coils, better transformers

Dual results frequently accrue from design improvements. In distribution transformers, for example, engineers have come up with a better method of winding coils from a manufacturing standpoint, and this method also results in improved performance of the transformers. The new method, called progressive winding, enables the continuous winding of high and low voltage coils in



one setup of winding machines. Actually this method, used for transformers of 50 kva and less, winds five or six coils at a time, all on the same mandrel, and all continuously. The operation starts with an insulating tube; then as the mandrel rotates, wire, spacers, and layer insulation are wound on progressively as the coil is built up.

Because of this winding method and other design changes, the impedance of these distribution transformers has been reduced to the range of 1.8 to 2 percent, compared to a previous average of 2.7 percent. Yet, because of the greater strength inherent in this type winding, these coils are mechanically stronger under short circuit.

A similar method is being used on distribution transformers of 75 kva and above. Here, however, instead of a group of copper straps, a wide copper strip serves as the conductor for the low-voltage winding. The net effect of these new winding methods is better coils that can be produced faster. ■

SWITCHGEAR

After several years in the lower arc-interrupting classes, sulfur hexafluoride gas has moved up with the heavyweights —the large high-voltage, high-power circuit breakers. A new 230 kv, 15 000 mva SF_6 breaker is the first of a line of high-capacity sulfur-hexafluoride-filled circuit breakers. The unusual arc-interrupting ability of sulfur hexafluoride gas has made it possible to design a breaker that combines the best features of insulating oil and compressed air designs. From oil breaker designs, the new breaker has borrowed dead-tank construction, positive mechanical connection between all contacts and operating mechanisms, and bushing-type current transformers. Like air breakers, the SF_6 breaker has lightweight, low-impact loading of foundations, and consequently light-foundation requirements. Since the unit is self-contained and does not exhaust to atmosphere, the breaker does not make the noise of an air breaker. Auxiliary apparatus normally required with air breakers has been held to a minimum.

Basically, each pole of the breaker consists of a round horizontal tank, with a bushing rising vertically from each end, and the interrupter mounted axially within the tank between bushings. Minimum dimensions are made possible by the high dielectric properties of sulfur hexafluoride. The gas readily recombines after arc extinction, resulting in negligible gas decomposition and extending time between maintenance periods. Being a ground-level tank, platforms are not required during installation and service work on the breaker. The interrupter consists of multiple-break contacts, tied together mechanically to a single operator, assuring simultaneous making and breaking of contacts.

The first breaker in this new line will be installed on the Pennsylvania Power and Light Company's system in mid 1960. ■

shelter for switchboards

Designers of switchboard equipment feel that with increasing construction costs, more and more utilities will be locating switchboards outside. To further improve the economics of outdoor switchboards, a new weatherproof enclosure has been developed. It provides complete weather protection for both operating personnel and equipment.

Previous weatherproof enclosures for outdoor type switchboards have consisted of a number of double-door units, placed in a row, so that each unit had an outside door both front and back. As a number of units increased, the result was a maze of weatherproof outside doors. Designers have therefore been looking for a new arrangement that would meet safety code requirements, but minimize the number of expensive weatherproof outside doors. They have come up with a single-unit design, which consists of a basic unit with an outside door at each end. As additional units are added, the end trim is removed, the additional units inserted, and the end trim replaced on the last unit. Hence, for each integral section of switchboard, only two outside doors are required.

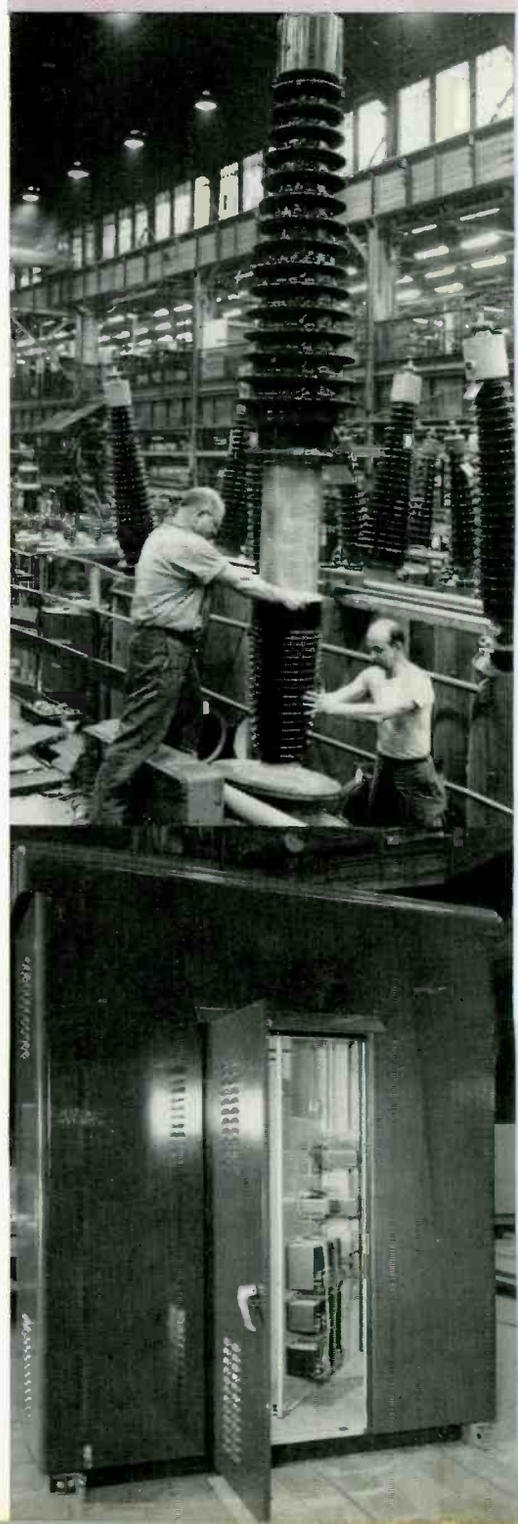
Inside, the switchboards are located on each side of a center aisle. The switchboard equipment is mounted on inside doors, which swing into the aisle to allow access to the rear of the switchboard. Fluorescent lighting across the top of the unit provides shadowless lighting. Crash-proof hardware is provided on the doors, so that although they are locked from the outside, only a push is needed on a release bar to unlatch the door from inside. ■

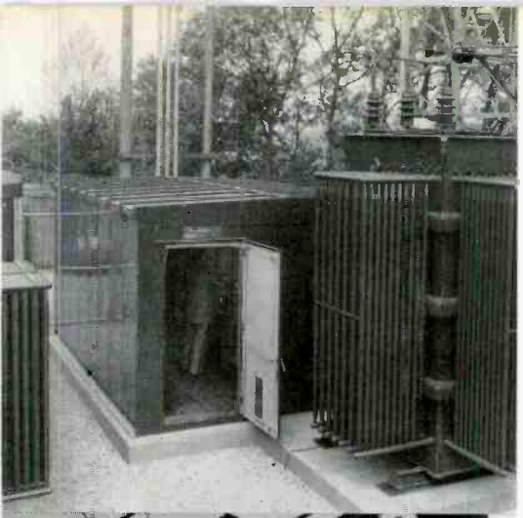
service area for Shelterfor-M

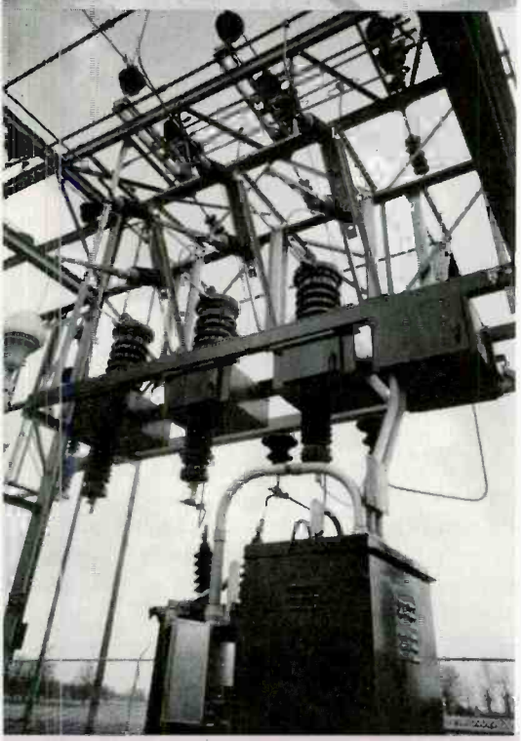
Switchgear designers have come up with a service area that is an integral part of the Shelterfor-M outdoor metal-clad switchgear structure. The service work area is obtained by extending the end enclosure of the Shelterfor-M housing. Standard three-foot sections provide flexibility and no vertical center supports are needed for extension widths up to nine feet. Normally, the standard nine-foot

Top—Approximately a year ago, the ASA standardized dimensions and certain design details for high-voltage bushings, so that bushings of various manufacturers could be used in both circuit breakers and transformers interchangeably. Shown here is the new Westinghouse Type O ASA standard condenser bushing being installed in a 230-kv power circuit breaker. The bushing is lifted from the top rather than from the flange, which gives a balanced load and avoids possible damage due to cable contact with the porcelain. The bushing design is mechanically adequate to support the lifting strains of this arrangement. The new bushing is now made in ratings from 115 to 196 kv.

Bottom—A new weatherproof enclosure for outdoor switchboards improves the economics of outdoor switchboards and provides complete weather protection for both operating personnel and equipment.







Top—Shelterfor-M weatherproof, metal-clad switchgear installed in the substation of Shenango Furnace in Sharpsville, Pennsylvania.

Bottom—First announced last year, this 46-kv recloser, employing sulfur hexafluoride gas as the arc-interrupting medium, is now installed on the Consumers Power Company System at the utility's Quincy Substation in Michigan. The unit operates much like a conventional low-voltage recloser; the device operates with three reclosures and four trips, with lockout after the fourth trip. Recloser tripping is adjustable from 150 to 400 amperes. The recloser has a 250-mva interrupting rating.

Each of the three porcelain-clad pole units contains an interrupter and single bushing. These pole units are assembled on a supporting frame. The solenoid operating mechanism, mounted at one end of the supporting frame, operates the three pole units simultaneously through horizontal connecting rods.

The interrupter assembly is a separate removable component consisting of the upper terminal, two-break interrupter, puffer, drive shaft, and moving contacts. The assembly is easily accessible; a special drive shaft coupling and current-carrying connector make possible its removal as a complete subassembly without the aid of a crane or hoist. The puffer, which is attached to the interrupter, is operated during closing, forcing fresh gas into the interrupter chamber after each operation.

addition provides ample space for station control batteries, tools, storage and other facilities. Location of control batteries near the breakers eliminates conduit runs and reduces voltage drops associated with long leads.

The service area eliminates the need for a separate structure—often a block building erected in a corner of the station plot—and improves the overall substation appearance, simplifying landscaping in crowded urban areas. ■

switch for disconnect switches

A special type of disconnect switch has been designed for grounding the line side of de-energized disconnect switches. Open during normal line operation, the new switch is closed to provide a ground point and drain off static charges that might be on an open de-energized line.

A second application of the new disconnect switch might be for sleet melting, to prevent overburdening of transmission lines with an ice load. The switch, connected to ground and coordinated with various schemes to limit the flow of current, is closed (with the line disconnect closed) to draw an overload of current. This current flow heats the transmission line and prevents an accumulation of ice.

The new disconnect uses a high-pressure contact employing silvered sponge-like copper ribbon. Three switches can be ganged for three-phase operation. The switch has a 600- and 1200-ampere current rating for 69 through 196 kv. The switch is remotely operated by mechanical linkage, and counterbalanced so that the operator has only to supply effort to overcome friction. Normally, the new switch is mounted on high-voltage disconnect switches or air-break switches. ■

big extension for recloser range

Previous interrupting ratings of the automatic circuit recloser provided 6000 amperes up to 400 amperes load current. The new recloser extends the range to 8000- and 12 000-ampere interrupting capacity with a load-current capability up to 560 amperes.

When used on 15- or 5-kv class distribution systems, the recloser detects and operates to interrupt a fault on the system beyond the recloser. After a definite brief pause, the unit recloses to restore power. If the fault has been cleared by this momentary voltage interruption, the recloser remains closed and returns to normal readiness. If the fault remains on the system, the recloser trips once again and recloses until a predetermined cycle of operations is completed, when it locks in the open position. Coordination with other protective devices is obtained with a preset sequence of instantaneous and delayed tripping operations. ■

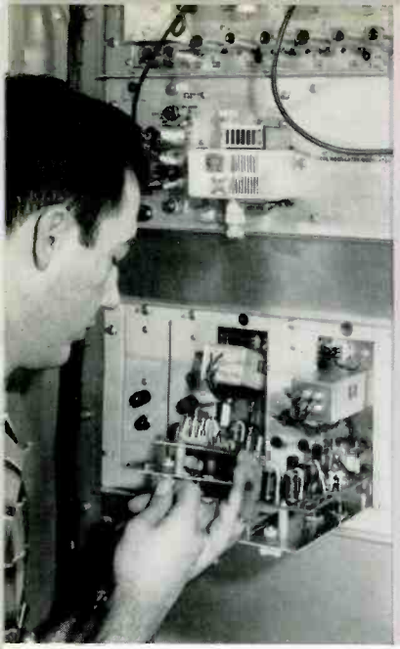
more kvar per package

Progress in low-loss paper with high dielectric strength has made practical a new 100-kvar power capacitor. Coupled with the size increase are some unique internal design features that reduce temperature gradients and permit longer heat paths. As a result, the 100-kvar design has dimensions practical for pole crossarm mounting and for Autotrol assemblies. The larger capacitor size reduces installation cost per kvar for pole-mounted banks, and in some cases permits more kvar on a single pole. Since the high rating doubles the minimum practical size of large high-voltage banks, the unit will be used primarily on relatively large banks. The 100-kvar capacitor has ratings in the 5 and 8.67 kv classes. ■

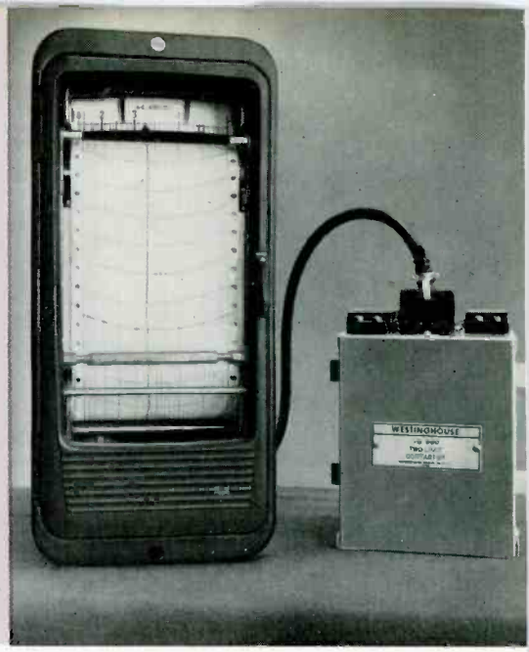
MEASUREMENTS, DISPATCH, PROTECTION

The key feature of a new automatic dispatching system developed by switchgear engineers is the integration of economics into the control of system generation to match load. New theories and techniques were developed and engineers are presently building a simulating system to test the principles involved. Actual dispatching equipment will be used, with simulated inputs to the equipment, and the output fed to a simulated power system. For example, a feature of the test equipment is a device that simulates the daily load curve of an electric utility; hence, problems of changes in load demand, variable in both amplitude and frequency, can be introduced into the dispatching equipment under test. The dispatching equipment feeds its control signals to equipment that represents the system's generators, so that accuracy and stability of the dispatch control system can be demonstrated. These laboratory tests on the new dispatching equipment are being run in parallel with analytical studies to prove the new automatic dispatching system.

The first complete Westinghouse Automatic Dispatching System will go into operation on the Southwestern Electric Power Company System in Shreveport, Louisiana in mid-1959. Controlling two stations, which is a large percentage of the total system generation, the system will automatically control swings and keep the system in economic dispatch. An automatic transmission loss computer



Left—New tone equipment (Type KA) for telegraphic functions has been completely transistorized. The new tone equipment uses three basic systems for transmitting intelligence: carrier on-off, amplitude modulation, or frequency shift. The equipment will use 18 frequencies in the audio spectrum. The transmitter converts the information to be transmitted into an audible tone, which can be sent over carrier, microwave, or wire-line circuits. The receiver converts the tone back into control signals to perform some telegraphic function, such as operating a remote motor, a teletypewriter, or for impulse-rate and impulse-duration telemetering. The first application of the new equipment will be on the Consolidated Edison system.



Right—This new transistorized device is designed for use with an indicating or recording instrument where a signal is desired when a limit is reached, either high or low, without imposing any load on the instrument. Fundamentally, the device consists of a transistor oscillator and two closely coupled oscillator coils, which have their mutual inductance changed when the moving element of the instrument causes a metal vane to move between the coils. The vane stops oscillation, causing a change in transistor current, which operates a relay. These limit switches are adjustable over the full-range of the instrument.

is used so that accurate values of bus-bar cost can be calculated. In addition, by means of a selector switch, the worth of power at all tie points and bus-bar cost of power at controlled and uncontrolled stations can be determined. This will enable the dispatcher to keep uncontrolled machines in economic dispatch, and evaluate interchange transactions. With this new dispatching system, the cost of generation can be kept to an absolute minimum. ■

hall multiplier measures watts

A brand new type of wattmeter uses a principle—the so-called *Hall Effect*—first discovered in 1879. As a result, the sensitive moving coil elements of the conventional electrodynamometer type can be replaced with a static transducer and a d-c indicating element. By using the new taut-band d-c instrument, the resulting wattmeter meets high shock standards.

Key to the new watt-measuring device is a tiny semiconductor crystal. A single-phase element is formed by placing one of these crystals in a magnetic field generated by the current being measured; the voltage being measured is placed on crystal surfaces to circulate a current through the crystal at right angles to the magnetic field. A charge difference, proportional to the product of current and voltage, is generated on the surface of the crystal in a direction mutually perpendicular to both magnetic field and current. The instrument voltage output is obtained by locating contacts on the charged surfaces.

Previous to the development of the semiconductor crystal, the Hall Effect output voltage was not enough to power an indicating element. The first application of the new watt-measuring device will be in a self-contained, circular-scale, 250-degree instrument. ■

no pivots, no bearings!

A hair-like metal band replaces conventional pivots and bearings in a new line of circular-scale switchboard instruments. This taut-band suspension system eliminates rolling or sliding friction, so that the only frictional loss is an infinitesimal amount of molecular friction within the taut metal bands. Furthermore, the shock resistance of the suspension mounting surpasses most stringent specifications for instrument performance. The new instruments are ideal for shipboard or locomotive applications, or mounting near large rotating equipment where severe vibration exists.

The moving element of the new instrument is supported at each end by a short hair-like band of a special high-strength alloy drawn to rectangular cross section. Measuring 0.005 inch wide and 0.0005 inch thick, the bands are dimensionally controlled to less than 5 millionths of an inch. The bands are permanently anchored to the moving element and to U-shaped springs that maintain proper band tension and contribute to immunity to shock and vibration. The taut-bands also carry current to the moving coil and, by providing restoring torque, eliminate the need for spiral springs. Sensitivity of an unusual degree is inherent—full-scale 250-degree deflection can be obtained with currents of only 50 microamperes.

Switchboard instruments making up the KX-241 line consist of d-c ammeters, milliammeters, and microammeters, and voltmeters and millivoltmeters. Frequency meters with transducers and a-c voltmeters of the rectifier type are also included. ■

new features for meters

New metal finishes and the use of a single-metal register design have given single-phase meters from two to five times more corrosion resistance than conventional units.

Essentially all components of the register are made of aluminum alloys, finished with a chromate-type conversion finish. The elimination of dissimilar metals and the use of a compatible finish on all components of the register removes the possibility of electrochemical corrosion under extreme environmental conditions.

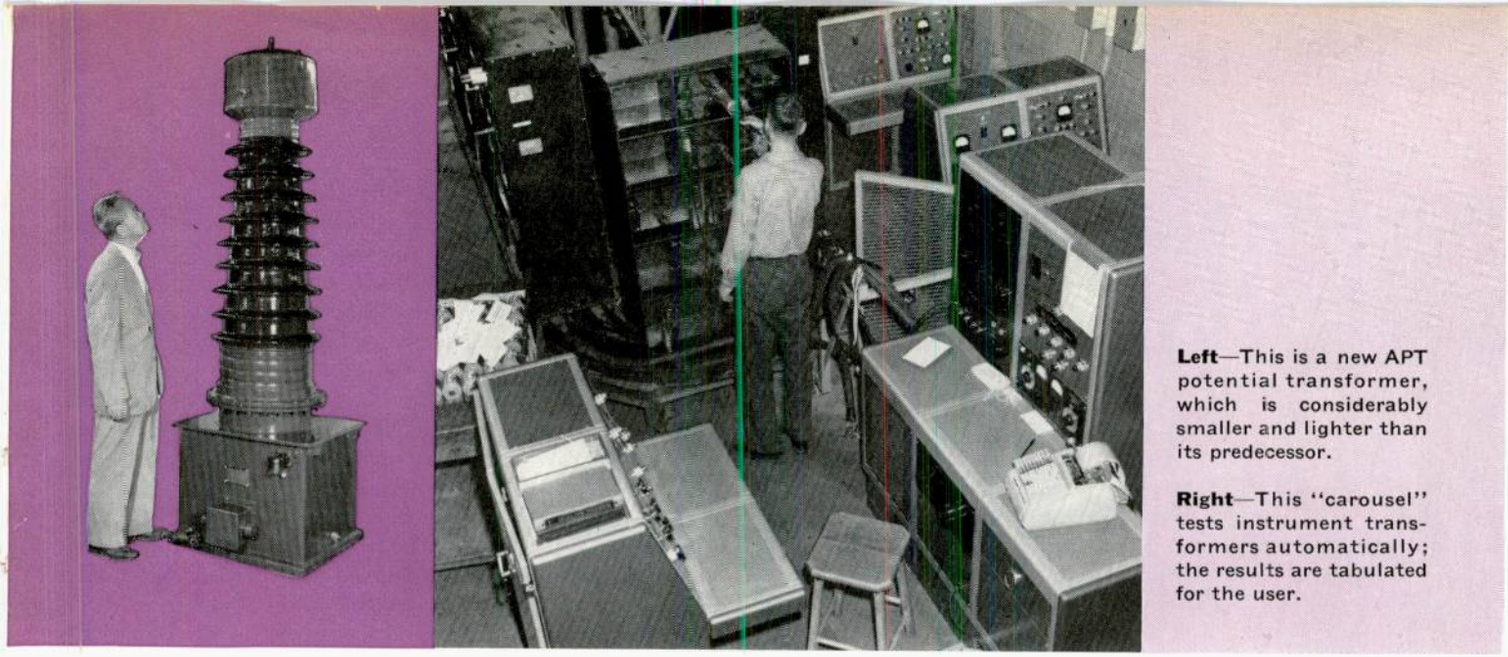
Corrosion has been minimized by use of a thermosetting epoxy ester enamel. This is the first effective use of an organic coating on aluminum meter frames. ■

inrush intelligence for relays

A new high-speed relay for differential protection of transformers recognizes differences between fault currents occurring within the transformer's differential zone, faults outside that zone, and the inrush currents that occur when transformers are first energized. For faults within the zone, the relay initiates tripping of the transformer breaker; it does not take action when it senses inrush currents or faults outside the zone.

Ability of the relay to discriminate between the three conditions results from the use of two circuit elements. A differential unit supervises the trip circuit on external faults, whereas a harmonic restraint unit takes over tripping responsibility when magnetizing inrush currents are involved.

Operation of the harmonic restraint unit is based upon the fact that inrush currents contain even and odd harmonics, with second harmonics (120 cycles) as a major constituent. When inrush currents are encountered, tuned circuits direct 120-cycle current to the restraint unit. If this second harmonic represents 15 percent of the inrush wave, the restraint unit perceives that inrush currents are



Left—This is a new APT potential transformer, which is considerably smaller and lighter than its predecessor.

Right—This "carousel" tests instrument transformers automatically; the results are tabulated for the user.

involved and acts to block tripping.

The new relay is the consequence of development work involving relay, transformer, switchgear, and utility engineers, all of whom played a part as the design progressed from stipulation of design objectives to field testing for data on the properties of the Kentucky Utilities Company and Cleveland Electric Illuminating Company. ■

for relaying, metering

Two new transformers have checked in for relaying and metering applications—one a new high-voltage potential transformer, the other a molded current transformer. The potential transformer (type APT) is smaller and lighter than previous units; for example, the 115-kv unit is 100 inches high to the tip of the bushing, has about 30 by 31 inch dimensions at the base, and weighs only 1950 pounds; this compares with about 108 inches in height, about 32 by 40 base dimensions and 3100 pounds for the previous unit. But these are not the only distinguishing features of the APT. An all-impregnated solid insulation system is used between high and low voltage coils, which among other things eliminates the possibility of electrical creepage paths. Another feature is the narrow spread of error over a wide range of burden; for example, it is less than 0.2 percent over the range from zero to 400 va, 85 percent power factor burden. The APT is built in ratings from 92 to 196 kv, with 450- to 900-kv BIL.

Tape-insulated current transformers are replaced by a new molded-insulation current transformer (type ECT) in the 2500-volt class. The core, coils, and frame of this new group of transformers are molded over completely with a new polyester elastomer material that has low power factor and high dielectric strength and is suitable for operation in oil. The process is a "one shot" proposition, with core, secondary coil and frames held in position by their base, and the primary coil by the primary bars. This method of holding assures accurate positioning of units within the molded plastic.

The new ECT units, in general, will carry 1.5 times their continuous current rating, as compared to the previous units which could carry no more than their continuous current rating. ■

carousel for transformers

The public utility commissions of many states require that instrument transformers for metering applications be tested for accuracy before installation. These tests must be performed and recorded by the user or by a certified testing laboratory, all at the user's expense.

Now automatic testing equipment not only makes all the necessary tests of the individual molded current transformers, but records these results on a card, which is furnished with each transformer. Transformers are placed on a carousel-type conveyor and moved to five different test stations where the individual tests are made. The position in which the transformer is initially mounted in the carousel receptacle determines the programming of the tests.

The transformer then moves automatically from station to station where impulse, primary applied potential, secondary applied potential, induced potential tests are all automatically performed and the transformer then moved to the ratio and phase angle test station where these tests are performed manually.

The results of the individual tests are stored in the master reader for future tabulation. After the ratio and phase angle tests have been performed, the complete test results are automatically typed on a card, certified by the tester and attached to the transformer for shipment to the user. ■

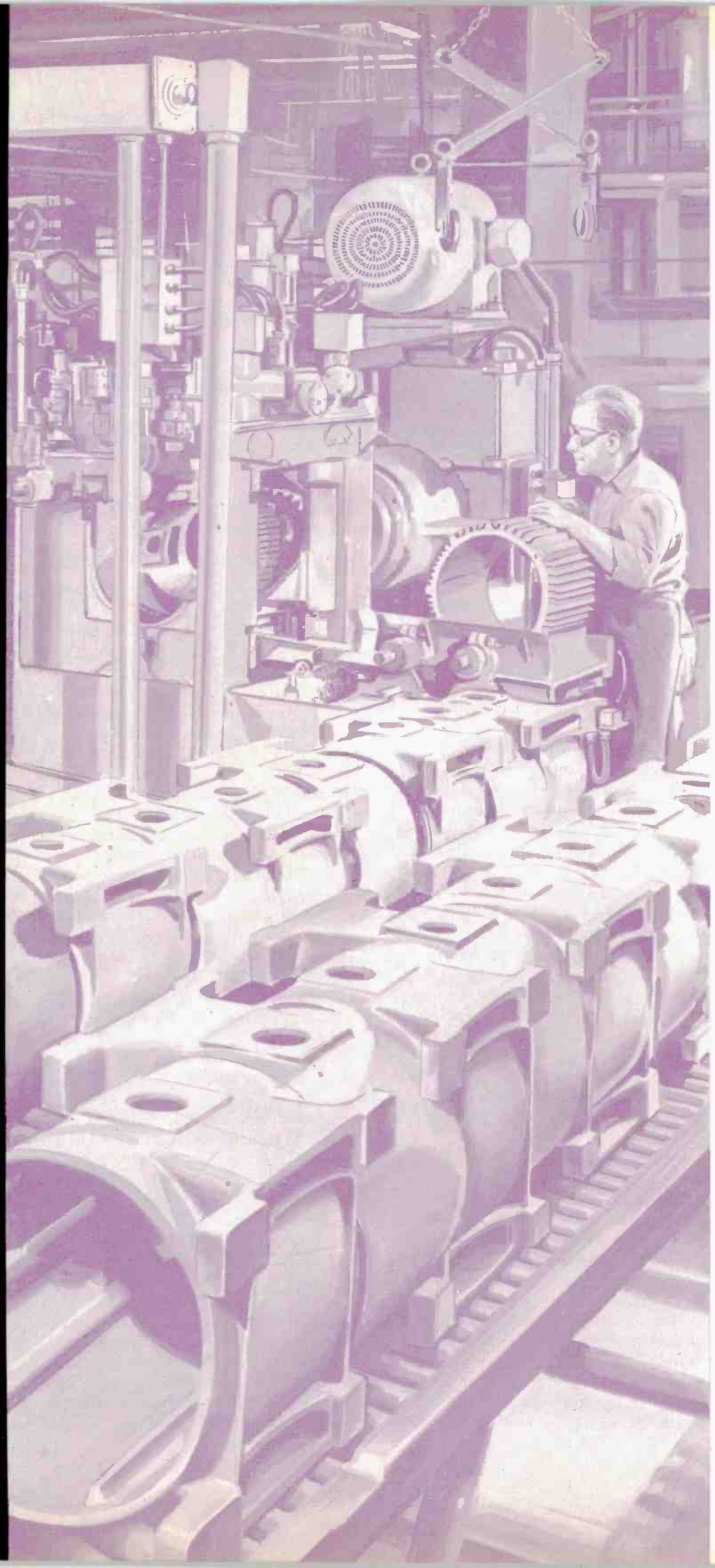
Cypak for boiler purge and shutdown

Nearly all the virtues of Cypak control can be covered in one word—reliability. But this one word takes precedence over all others where control of the shutdown and purge cycle in a utility plant is concerned. Any failure to annunciate a fault or shut off fuel supply promptly can result in serious damage to the plant.

For two units at the Sterlington Plant of Louisiana Power and Light Company, separate Cypak systems are designed to continuously monitor a total of seven boiler conditions for the number five unit, and five boiler conditions for the number six unit. Among these are: gas valve opening, fan operation, fuel pressure, windbox differential, and furnace draft pressure. A fault in any of these is immediately indicated by panel lights and the fuel supply is automatically shut off.

After the fuel has been shut off, either manually or by a fault, the Cypak system prevents the purge cycle from being started until all faults are cleared, minimum ignition pressure and air flow are obtained, all registers are opened and all gas valves are closed. Having met these conditions, an indicating lamp on the control board shows that the purge cycle can be started. A purge timer is set for a minimum time of a few minutes to assure that all gases are out of the system. After the purge is completed, the fault light turns off, the master fuel trip relay is reset, and a light indicates that normal operation can be resumed. Only then does Cypak permit the operator to close all air registers to relight the boiler.

Ebasco Services Incorporated were consulting engineers and managed the construction work for Louisiana Power & Light Company. ■



DRIVES AND CONTROL

To the already proven merits of the Magamp speed regulator for ignitron-powered motors is added another feature—standardization. In doing this, engineers have made other significant changes. First, a standard field exciter is used so that the Magamp regulator is made independent of the size of the motor. Secondly, a two-stage push-pull 400-cycle Magamp controls the field exciter, resulting in higher gain, faster response, and $\pm 1/4$ percent regulation. Now one standard speed regulator can be applied to any ignitron-powered motor.

Much space has also been saved with the new design; the stand cubicle has been reduced from 72 inches to 44 inches in depth. Main circuit meters are located on the front door, relays on the inside panel, and regulators on the rear door. With the rear door open, all voltage points for a given motor control are available for test and measurement. ■

completely static variable-voltage control

Moving parts shorten a motor control's useful life. In view of this, engineers have developed a static threesome of silicon rectifiers, power reactors, and Magamp regulators for variable-voltage control of d-c motors (Reactifier drive). Its response is just as fast as its rotating predecessor—the m-g set.

The operation of the new control is simple. The motor can be started and stopped by an a-c contactor in the three-phase line. The reactor power windings and silicon diodes are connected in a modified three-phase bridge to control the motor armature supply. The silicon diodes provide self-saturation of the power reactor in addition to their usual job of rectifying the a-c power. The armature current and voltage are obtained by varying the d-c current in the control windings of the power reactors with Magamp regulators. The degree of reactor saturation then determines the output voltage to the motor. Armature voltage and current signals are fed to the Magamp windings to provide a counter-emf type regulator with current limit during acceleration.

The new Reactifier drive has been made for 1 to 200-hp motors, operating on either 50 or 60 cycles. A supply of three-phase 208/220 or 440-volt power can be used. The unit can provide constant torque over an 8 to 1 speed range, but a constant-horsepower speed range can be obtained with motor-field control. ■

Prodac control

Since its first application in the Jones and Laughlin's Alliquippa Works in Pennsylvania, Prodac control has lost no time in finding other applications in the metal-working industry.

At the Jones and Laughlin's reversing roughing mill, a single IBM punched card contains all information needed for a single schedule, from the time the billet enters the mill, passes through a maximum of nine reversing roughing operations, and exits to the following hot-strip mill.

A similar system to be shipped to the Nippon Kokan K. K.'s Mizue Works near Tokyo will be the first overseas application of Prodac control and Japan's first automatic steel mill. When completed in 1959, the reversing rougher will be part of a new 68-inch semi-continuous hot-strip mill designed to roll hot carbon-steel strip. The 6000-hp main mill motors will rough billets at speeds up to 1100 feet per minute.

By far the largest installations of Prodac control to date are a slabbing mill at the Gary Works and a blooming mill at the South Works of the United States Steel Corporation. The 46-inch universal slabbing mill at the Gary Works prepares incoming billets for a hot-strip mill. Information from the cards then automatically controls the screwdown, roll tables, edger opening, manipulators, and fingers for turning the steel billets. Also the direction and speed of the mill is automatically controlled. Due to the amount of information needed for each schedule, magnetic core planes are used to store information from the punched cards.

A 52-inch reversing roughing mill at Empire Reeves Steel's Mansfield Plant has its screwdown control automatically adjusted by Prodac control for a total of nine passes in any one schedule. This 5000-hp mill feeds a hot-strip mill.

Prodac control also appeared in the aluminum industry. This year saw the 160-inch reversing mill go into operation at Alcoa's Davenport plant. Here Prodac control maintains the screwdown and mill speed settings for any one schedule of up to 25 passes. Also provided is a scoreboard for the operator that displays: the alloy number, ingot size, pass number, rolled width, and an indication to lengthen or widen the slab as it is rolled both broadside and longitudinally. ■

new a-c adjustable-speed drive

Last year engineers did a sleight of hand that would put the best of parlor tricksters to shame. The props—a wound-rotor motor, d-c motor, and semiconductor rectifiers. A pass of the wand and—a new a-c adjustable-speed drive—its performance useful and unique but not characteristic of either motor. This packaged Rectiflow drive provides continuously variable speed control over speed ranges of 1½ to 1, 2 to 1, or 3 to 1 with a maximum speed of 1690 rpm. The unit has a characteristic constant horsepower over the entire speed range, but can also be made for constant torque.

Here's the secret. A wound-rotor motor and d-c motor are coupled on a single shaft. A set of semiconductor rectifiers then converts the slip power of the induction motor to d-c, which is then supplied to the armature of the d-c motor—putting the slip power to useful work. An additional set of rectifiers converts power from the a-c line to direct current for the d-c motor shunt field, allowing the package to be operated on any standard a-c voltage and frequency—hence the name a-c adjustable-speed drive. A rheostat in the d-c field makes it possible to control speed simply by adjusting the field strength of the d-c motor. If, for instance, the d-c field is open and the Linestarter closed, the induction motor attains synchronous speed. But by applying a field on the d-c motor, the counter-emf in the d-c armature blocks the small current through the rectifiers and d-c armature that was necessary to overcome friction. The drive then slows down, the slip voltage increases, and the counter-emf voltage of the armature decreases until the slip voltage is just high enough to circulate current through the a-c rotor and d-c armature to again overcome friction. If when operating under a constant load, an increase appears, the slip voltage also increases and armature counter-emf decreases, to permit more current to flow until the required torque is obtained. ■

tire testing dynamometer

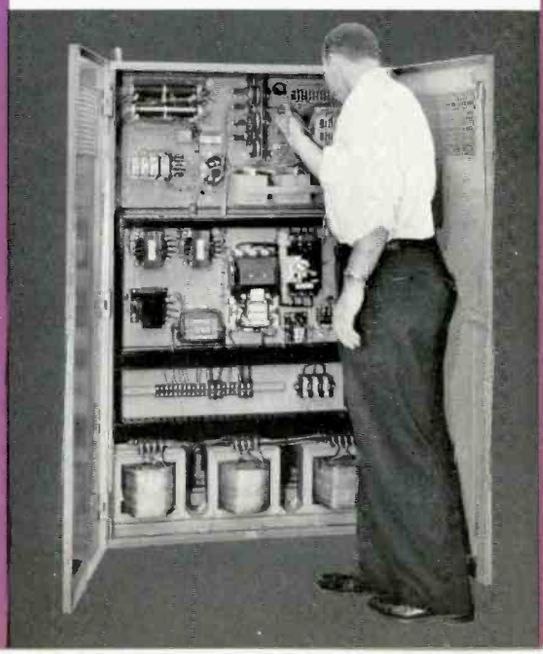
As jet planes clock up higher speeds, engineers are faced with a "tire" as well as a heat barrier. With longer runways needed for take off and landing, and higher speeds required to get the plane aloft, airplane tires have to survive an unusual amount of punishment.

To improve tires for planes of the future, the U.S. Rubber Company subjects them to a grueling test on an Adamson United Company dynamometer, which is controlled with a Magamp regulator. Instead of making flight tests, which might be dangerous with experimental models, the tire is kept stationary and the "runway" moved. The runway is

Though bags make a handy container, the full bags are difficult to handle. But this Cypak controlled Miller bag palletizer automatically stacks interlocking layers of bags into a neat easily handled pile. The Miller Engineering Corporation is located in Louisville, Kentucky.

Above—An offbeat but appropriate Cypak control application this year is at New York International Airport's parking lot. As a driver approaches the lot, a magnetic coil beneath the road causes the ticket dispenser to stamp the date and time on a ticket. As the driver takes the ticket from the machine, the parking lot gate raises. The gate closes as the car passes over a second coil.

Below—A static control for d-c motors (Reactifier drive).



an 8-foot diameter flywheel driven by a 1250-hp motor. During a "take off" the tire is pressed against the wheel with a force equal to the weight of the plane; the motor is started, moving the flywheel. Simultaneously the pressure on the tire is decreased to simulate the lift of the plane.

Control of the motor is especially interesting during landing. The flywheel is rotated at a peripheral speed of 300 mph; the tire is not rotating. Then to simulate the impact of landing, the tire is pressed against the flywheel with a force that may reach 80 000 pounds. Almost immediately the tire attains top speed, putting a severe brake on the motor. The Magamp regulator however, keeps the motor running at its predetermined speed. ■

unattended pipeline pumping

An eight-inch petroleum products line from Salt Lake City to Spokane, Washington is now running smoothly with only two supervisory control points. Fuel oils are pumped through two parallel lines from Salt Lake to Boise, Idaho. One line has four unattended pumping stations along its length. The other has one. The supervision for these stations is in the Salt Lake dispatching office. The supervision for the two unattended stations between Boise and Spokane is at the Boise pumping station. Because of storage tanks at Boise, the two sections can be operated independently.

To give a constant check on the unattended stations, both the suction and discharge pressure of each station and the discharge pressure of each pump are telemetered to the supervisory location. In addition, equipment condition is monitored and such abnormal conditions as excess pump seal leakage, high motor temperatures, high transformer temperatures, incomplete sequencing of automatic operations, and power failure are automatically reported at the respective dispatching office. Telemetering is done using pulse-duration techniques, the information being given to the telephone company in the form of audio-frequency tone pulses for transmission and reproduction at the far end of the circuit. Certain essential conditions are continuously telemetered; each is assigned a specific audio frequency.

Each station, and each pump unit, can be controlled remotely. Pumps can be started and stopped on demand and pressure set points can be adjusted. The equipment at each pump station is self-protecting and if operating conditions go "out of bounds" the unit or station will automatically shut down. If the condition is transient in nature (e.g., low suction pressure), the equipment can be restarted remotely; however, if the off-limit condition is indicative of an equipment failure (e.g., excess seal leakage), the equipment is "locked out" and the starting circuits must be reset locally.

Remote control and supervision is effected by Visicode supervisory control. This system represents point of supervision or control by a two-digit number. If an operator must adjust pressures or stop or start a pump unit, the operator presses the pushbutton on his control panel corresponding to the device. The control system automatically sends trains of pulses to select and check the selection of the device. The operator then presses the pushbutton corresponding to the desired operation. Again the equipment sends a train of pulses initiating the control action. When the control action has been completed a final train of pulses is returned, which causes an indication to appear on the control panel. ■

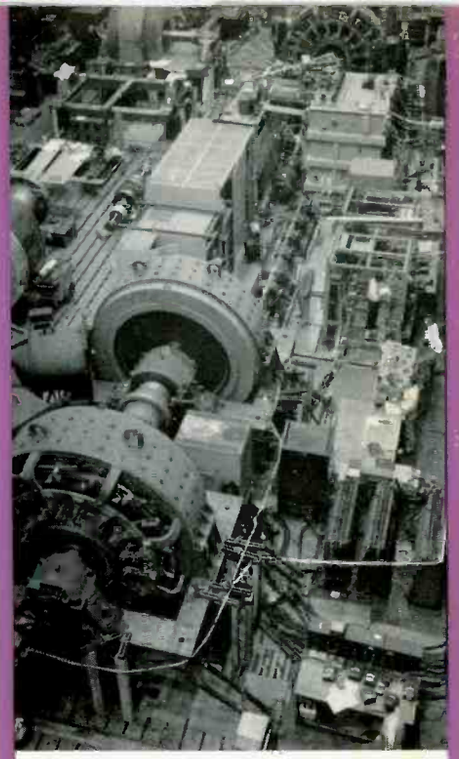
new electric governor

After several years of concentrated engineering, a new electric governor has been unveiled. The new model (EFG) consists of two major components: an electric control unit, and an electro-hydraulic actuator. The governor operates solely by electrical frequency (speed) sensing. The heart of the system is an advanced magnetic-amplifier element that greatly reduces the time response required by the magnetic amplifier, providing increased sensitivity and stability to the system. Tests on various sizes and types of engine-generator sets indicate considerably improved performance over earlier models without the requirement of load sensing. Advanced design techniques also provide a much smaller and lighter unit than earlier models. ■

high steam conditions for medium turbines

The City of Detroit, through their Public Lighting Commission, can lay claim to the "biggest little" turbine in the world, a 50-mw steam turbine with exceptionally high-steam conditions for a turbine of this rating—steam inlet at 1800 psig, 1050 degrees F, and 1000 degrees F reheat. Six stages of feedwater heating are utilized, as compared to five stages normally employed for a unit twice this size. As a result, exceptional performance will be realized for a unit of this size.

A 9375-kw turbine will use steam at 1425 psig and 950 degrees F, with 400



The equipment shown is a complete mill drive with all the components for one stand of a 66-inch hot-strip mill. To make steady-state and transient tests on the complete combination of equipment for the stand at East Pittsburgh, all the components were gathered from the many manufacturing centers, assembled and completely wired as though being installed in the customer's plant. This unusual combination test of all stand components was taken on equipment for a four-stand mill of Aceros Planos de Monterey, SA. in Mexico.

Model of Pittsburgh's civic auditorium, which will be capped with the world's largest movable dome—415 feet in diameter. At the touch of a single control button, six roof leaves will move at differential speeds to arrive at the open or closed position in the same time—2½ minutes! The leaves will move at predetermined, synchronized speeds, governed by speed and horsepower of each leaf's five electric drive motors and by individual reactor controls for each leaf.

psig extraction and 130 psig exhaust pressure. This unit is being installed by the Rhinelander Paper Company. This set of steam conditions fitted in with steam conditions in the Rhinelander Mill; the turbine acts as a topping unit for others already in service. ■

emigrant gas turbines

Industrial gas turbines are migrating to some interesting applications. In Mexico, an 8500-kw turbine will generate electric power for use in the steel plant of Altos Hornos de Mexico. The exhaust gas from the unit will pass through a boiler, which will produce steam to drive a steam-turbine air blower for the blast furnace. This is the first time a gas turbine has been so applied, and will result in high overall plant efficiency.

Four 5000-kw gas turbines will generate electricity for a state-owned municipality in a remote mountainous part of Brazil. The turbines will burn a residual oil with a high percentage of vanadium, calcium, and sodium salts, which if left untreated can be extremely harmful to the engine. Therefore, along with the turbine, a treating system will be supplied to neutralize these harmful salts.

In Venezuela, Westinghouse will build the first gas-turbine power station with completely automatic remote controls for Compania Shell de Venezuela to power an oil storage and tanker-loading facility on Lake Maracaibo. The station consists of two 5000-kw turbine-generator units, which will power nine 1500-hp pumping motors. Capacity of the installation will allow handling initially 700 000 barrels daily and eventually well over one million barrels per day. By using remote controls, the same man can run the turbine and the oil-distribution system from a single point. To assure continuous operation, the turbines can switch to diesel fuel should there be a failure in the gas supply.

Also on Lake Maracaibo, the Creole Petroleum Corporation has completed their third, and are now building their fourth, "island" to add further capacity to their gas conservation plant, which maintains pressure on their underground oil fields. Seven turbine-compressor units will be located on each platform with provisions for seven more when needed. Each gas turbine is an 8000-hp unit and will drive a centrifugal compressor. Natural gas, which has come out of solution from the crude petroleum that has been brought up from the oil reservoir, will enter the pumping plant at a pressure of 30 pounds, go through the compressors in series, and return to the oil reservoir at 2000 pounds pressure. Hence, the pumping stations serve two purposes—the oil fields are kept under pressure and gas is conserved for future use. ■

CONTROL AND DISTRIBUTION DEVICES

As usual the field of devices for low-voltage circuit control shows a long list of improvements and first appearances. Here are a few from last year:

Select-O-Lite—By combining the functions of a two-position selector switch and indicating light, the Select-O-Lite makes possible a 50 percent saving in panel mounting space. The light is located in the head of the selector switch. A typical application would be an on-off switch with the light indicating power on. The switch has ratings of 120- to 480-volts a-c and 6- and 125-volts a-c or d-c.

Vinyl-Insulated Low Impedance Busway—Low impedance buswork can now step into a number of new jobs because of a new insulating material—a tight fitting vinyl tubing. This makes ventilated outdoor busway a practical reality, as the vinyl tubing is completely waterproof. Also, the vinyl easily resists acids and alkalies. Previous bus bars coated with varnished cloth and other tapes were extremely limited in these areas.

This development was made possible by a new manufacturing technique. The vinyl tubing is stretched as it is formed and "frozen" in its enlarged state. After it is fitted on the bus bar, heat is applied and the tubing returns to its original size. The insulation is applied to busways with ratings from 600 to 5000 amperes.

Saf-T-Vue Interlock—Saf-T-Vue and other standard breakers can now receive an added measure of safety with an interlock that prevents the breaker from being thrown on when the cover is open.

When the cover is opened the interlock automatically moves in front of the breaker handle, and to prevent tampering, provision is made for several padlocks. When the cover is closed, a cam automatically moves the interlock from the breaker handle. The interlock can be applied to any breaker operated by a front-mounted toggle-type handle.

Three-Pole Quicklag Breakers—The family of Quicklag breakers is now complete with the addition of the three-pole unit, bringing circuit protection to one-two- or three-phase lighting or light industrial systems. Triple-pole breakers have been obtained in the past by linking the handles together by means of handle ties and obtaining single-pole tripping. But now, because of a newly developed cradle tie bar assembly, simultaneous tripping of all poles can be obtained.

The unit protects three-phase 240-volt systems with maximum fault currents of 5000 amperes. Inverse time delay is provided on overloads and high resistance faults from the current rating to 5000 amperes. Ratings of 15, 20, 30, 40, and 50 amperes are provided in both bolted type C and stab-in type P construction. ■

control panels made of steel

For years d-c control panels for steel mills have been made of ebony, asbestos, or slate. While these materials provided adequate insulation between controls, all were on the heavy side and could be broken in shipment. The lighter and stronger steel could not be used because a bushing was not available for insulation between the control studs and panel.

The use of steel has now been made possible with the perfection of a glass polyester bushing. This device, which fits between the stud and panel, has been designed with several different diameter sections. While iron and slag dust can collect on the top surfaces of each section, none is found on the vertical surfaces. Thus electrical creepage is eliminated as there is no continuous layer of dust across the surface of the bushing.

Not only has the panel been strengthened and lightened with steel, but several other advantages have been incorporated in the new design. All control connections are made on the front of the panel, and control wiring has been neatly tucked away in Micarta channels. If control changes must be made, the cover can be snapped off, and wires easily traced. This front-wiring scheme leaves only main copper connections on the rear of the panel, providing access to the main connections, shunts, and small resistors. ■

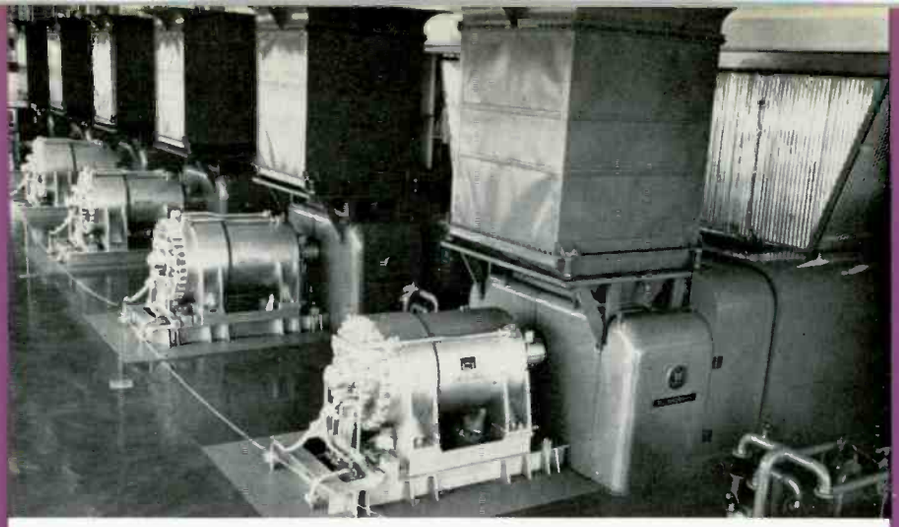
MOTORS

If ever a device had hidden talents it's a new submersible pump motor. It operates deep in a well, "over its head" in water, driving a pump just above it.

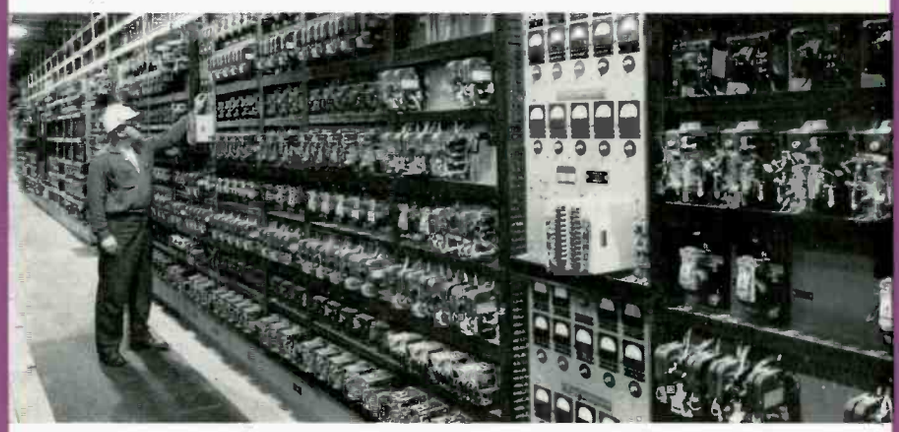
The new motor takes to water like a skin diver. Not only does it operate submerged, but also (unlike a skin diver) literally full of water; moreover it uses water as a lubricant for its thrust and guide bearings.

All this required a bit of doing. In the first place it required a special waterproof insulation system. Each wire in the winding is plastic covered, and the joints are potted with epoxy resin. This system maintains an insulation resistance of hundreds of megohms. At the same time it permits the water to serve as a heat transfer medium.

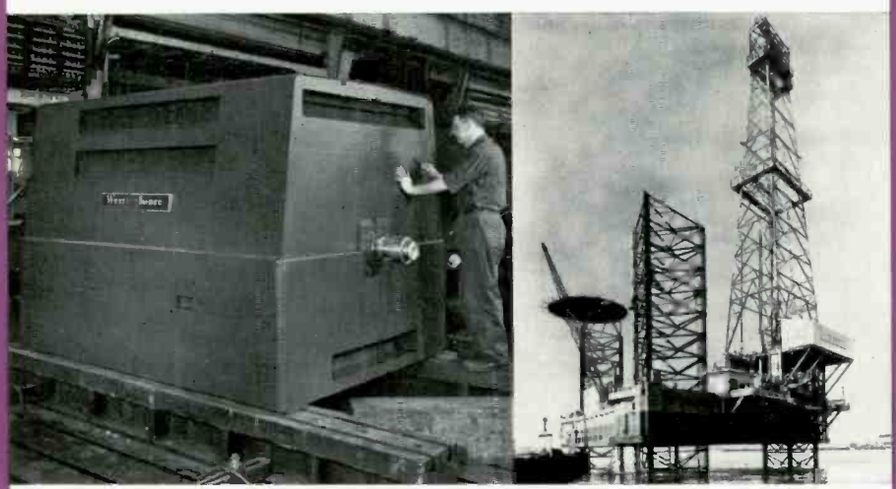
The water-lubricated thrust bearing easily handles extremely high-thrust



These 8000-hp gas turbines pump gas back into underground oil reservoirs under a pressure of 2000 psi.



Electrical control panels for the new U. S. Steel electrolytic tinning line installed by Columbia-Geneva Division at Fittsburg, California. Thousands of controls are used to operate the new equipment, which can produce tin plate for the canning industry at speeds up to 1250 feet a minute.



The new F/A motor was introduced in mid-1958. Utilizing a new concept in large a-c motor design the wound stator is a component independent of the motor housing. Hence, the wound stator is fully accessible for inspection and maintenance. Already on the drawing board or in the shop are practically every type and size of motor that will be built; this includes horizontal squirrel-cage, wound-rotor, and synchronous motors from 250 to 7000 hp. The largest motors completed to date are three 4000-hp squirrel-cage 3600-rpm motors, operated at 4000 volts. They are being installed in the Alabama Power Company's Barry Steam plant, and will drive boiler feed pumps.

Instead of hauling a line of boxcars, three traction-type d-c motors and generators climbed aboard the Dixilyn Drilling Corporation's offshore drilling rig, "Julie Ann," to hunt for oil. The drawworks of this 25 000-foot rig is powered by two 1000/1600-hp traction-type d-c motors which receive their energy from three traction-type generators. The use of these motors and generators specifically designed for off-shore drilling, allows the highest available horsepower per pound equipment to be packed into a minimum deck space.

loads; it has been tested at 4500 psi, but engineers believe that it is capable of handling even higher loads. The bearing is made of a special "wettable" material that enables water lubrication.

The motor has several other advantages. For one thing any noise is literally drowned. Line-shaft losses associated with most other pump motors are eliminated. Since windings are not sealed like other submersible motors, no problems can arise on this score. As far as is known, this is the only fully wet, large motor being produced in this country. Present sizes are 40 to 75 hp, but motors up to 450 hp are contemplated. ■

for the home . . .

Sometimes overlooked is the increasing number of jobs performed by electric motors in the home. The design problems in these motors are of the same magnitude as for any industrial application.

One new motor designed last year is for home appliances, such as washers and dryers. This replaces a motor designed for wider application. The advantages of design for specific application accrue in lighter weight, better starting performance, shorter length, and better ventilation, among other things. The motor is designed for operation in any position.

The new motor is being built in one-sixth, one-fourth, and one-third horsepower ratings for either split phase or capacitor start. Both single-speed (1725 rpm) and two-speed (1725/1140 rpm) motors will be built. Motors are rated at 115 or 230 volts, 50 or 60 cycles.

Another new motor is designed for air-moving equipment, such as domestic furnace blowers. This is actually a larger motor, electrically speaking, on an existing frame size (42). Refinements in design techniques and manufacturing methods have made it possible to obtain shaded-pole motors on this frame size with higher efficiency (lower losses) than previous units. The motor is intended for low starting torque, air-over applications. Technically, it is a shaded-pole motor, and the present ratings extend from one-twelfth to one-sixth horsepower, six poles. ■

new class of switching thermistors

A new family of ceramic solid-state devices that can be used as contactless thermal switches are being developed by the Materials Engineering Department. They will be the first such components suitable for industrial use. There are many opportunities for applying the new devices, particularly in applications where it has been impractical to use bimetallic

temperature-sensing elements.

Motor engineers have used these "switching" thermistors to develop a new Guardistor system for protecting motors against overheating. In this system—the first new approach to motor over-temperature protection in many years—thermistors installed directly in the motor windings operate a small external relay, which de-energizes the motor or gives a signal when overheating occurs.

Such applications of the new positive temperature coefficient (PTC) thermistor are made possible by its unique ability to display a sudden, substantial increase in resistance when its temperature rises to a characteristic switching level, and its ability to return to normal resistance when it cools below that level. Thus, when operated above its switching temperature, it acts as a high resistance; when below it, as a low resistance.

By varying the composition of the PTC thermistor during manufacture, it is possible to precontrol both its residual resistance and the temperature level at which switching occurs. Thermistors being designed for motor over-temperature protection can switch at specific temperature ranges between 100 and 125 degrees C, and can function in control circuits taking advantage of its over 20-to 1 ratio of maximum to residual resistance.

Although designated as PTC thermistors, the new devices differ from commercially available thermistors in that their temperature coefficient of resistance is positive, whereas that of the common commercial NTC thermistor is negative. This positive characteristic permits a simple temperature-protection control that has maximum fail-safe protection. Other contrasts are these: Within their respective operating ranges, the sensitivity of PTC thermistors is many times that of the NTC thermistors; and operational temperature ranges for PTC thermistors are very sharply defined and are controllable. ■

epoxy linkages in thermalastic

New tape bonds and impregnating resins, which contain epoxy-like molecular linkages, have been coupled with the basic Thermalastic insulation concept, resulting in improved stator coil insulation for hydrogen-cooled turbine-generator windings. Improved resins have raised permissible temperature for equal life by more than 20 degrees C, and the cellulose backing for the mica tape became the limiting factor for temperature classification and thermal endurance.

New sources of supply were developed to provide a thin glass fabric equal to the thickness of rope paper. This permitted the creation of a new Thermalastic insulation combination consisting entirely of mica splitting, thin glass fabric, and the high thermal endurance resins. Several windings employing the advanced form of Thermalastic insulation were built during 1956 and more in 1957. Installation and service experience has proved the new form, and it is being extended to other machines.

For Motors—Resistance of Thermalastic insulation to weather, moisture, and other contaminants that have adverse effects on conventional insulations have been the outstanding advantage for motor application. Proof of this has been experienced with motors that have provided satisfactory operation under severe ambient conditions, where contamination is a limiting factor. As a result, motors with only dripproof frames are how being applied in many places where totally enclosed designs are required with conventional insulations.

Functional Evaluation Tests—New industry standards have presented new concepts of insulation classification, involving functional evaluation of insulating materials and systems in the "as used" condition on actual equipment. This permits insulation designers to make a more realistic appraisal of insulation in the laboratory. A wide variety of materials are presently undergoing evaluation, to provide insulation engineers with a wide background knowledge. The Thermalastic insulation concept was one of the basic developments that came out of this continuing study. ■

WELDING

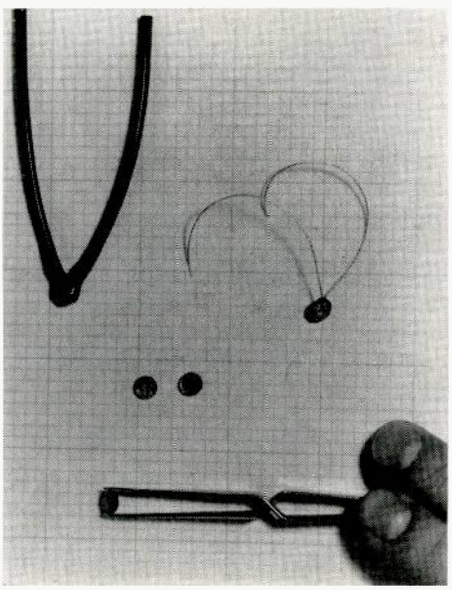
Research into the electromechanics of weld-metal transfer in gas-shielded welding processes has led to a new type of power supply equipment, bringing the advantages of CO_2 welding to many new industrial applications. Suitable for use with any standard constant potential, constant wire-speed system of metallic-inert gas welding, the new Dynamic Reactors are compact, static, two-terminal packages that can be connected in series with either of the current leads.

By limiting the rate of rise of weld current, the new reactors permit the use of lower weld currents and the transfer of weld metal in droplet form. In turn, lower currents and droplet transfer permit the use of larger and less expensive wire sizes, effective depth control of weld penetration, and, for the first time, the use of the CO_2 process for vertical and overhead welding.

Basically, the new development grew from recognition that the high welding currents normally characteristic of the CO_2 process were necessary to prevent creation of globules of molten metal capable of short-circuiting the arc. When such short circuits occur, the constant-potential power source produces very high currents, whose magnetic forces can disrupt the globules and throw them from the arc region as spatter.

The dynamic reactor inhibits growth of these short circuit currents and allows weld metal to be melted for smooth transfer to the pool on the workpiece.

When applied to automatic and semiautomatic welding equipment, the new reactor makes it possible to reduce minimum welding current by a factor of more than two to one. And in existing applications, savings in wire costs will usually be significant since direct substitution of wire at least one size larger is possible with little or no change in current, voltage, and travel speed.



End product of PTC thermistor: thermistors with metallic contact surfaces applied and with leads attached. Black wishbone at upper left is unit in one variety of thermistor encapsulation.

Reductions in weld current ranges give the CO_2 process ability to join thinner metal than formerly was practical.

Dynamic Reactors are of two sizes: The smaller—dual-rated at 150/300 amperes, 100-percent duty cycle—is for nominal gauge materials in semiautomatic setups and for semiautomatic or full-automatic welding of thin gauge materials. The larger unit—dual-rated at 300/600 amperes, 100-percent duty cycle—is for high-speed automatic or high-current semiautomatic applications. ■

LAMPS AND LIGHTING

Several years ago, research engineers developed a new phosphor that, coated on the inside of a mercury lamp bulb, converted much of the invisible ultraviolet to visible red light. This resulted in a color-corrected mercury lamp (J-H1), which produced white light instead of the characteristic blue-green of ordinary mercury lamps. For places where high output and white light are highly desirable, lamps of this type, in various sizes and shapes, have proved a real success. This method of color correction, however, means a slight reduction in lumen output compared to clear-bulb mercury lamps.

Lamp engineers soon recognized the need for an "in-between" lamp, one that afforded somewhat less color correction but somewhat greater lumen output. In the new Colortone high-output white lamps they came up with the answer they were looking for. A new phosphor not only adds red to the lamp's output but also adds light throughout the entire visible range—so the net result is a higher lumen output than for either the clear E-H1 or color corrected J-H1. For example, the 400 watt J-H1/SW produces 23 000 lumens compared to 21 000 lumens for the corresponding clear lamp—or a 10 percent improvement. The new mercury lamps are now available in sizes from 100 to 1000 watts, in regular, semi-reflector, and Weather Duty bulbs. ■

mercury gets new life

In mercury lamps, the end of economic life comes when light output diminishes past a certain point. Beyond this point the lamp will still produce light, but in steadily decreasing quantity. Cause of this lowered light output is the "boiling off" of electrode material, which deposits on the glass arc tube, eventually building up to the point where it blocks large amounts of light.

A new arc tube for mercury lamps, aptly called the "Lifeguard" tube, greatly reduces this effect, thereby giving the lamp much longer useful life. The trick here was to find a way to have an electrode with good electron emission characteristics but at the same time lessen the vaporization. To accomplish this, a primary coil is treated with a special emission material; then a second coil is screwed on over the first coil. This seals in the emission material as far as vaporization is concerned, but still allows electrons to be emitted. As an added feature this electrode coil assembly is larger than previous units, which means it runs cooler and has less tendency to boil off bulb-blackening materials. To round out their development, engineers also came up with a new end seal for the arc tube. This seal is formed by a "one-shot" method, rather than the more complicated several-step operation previously used, and therefore is inherently more reliable.

Substantial improvement in economic life is achieved by the new arc tube. For example, at the end its rated economic life of 7000 hours, the standard 400 watt E-H1 has a lumen output of approximately 70 percent of initial value. The new lamp, at the end of the same time, is still producing close to 90 percent of its initial rated value.

As a result, the economic life of the new Lifeguard mercury lamps has been raised to 9000 hours. The new tube is being applied first to 400-watt Weather Duty varieties, but may eventually be extended to all mercury lamps. ■

incandescents also improve

Despite their long history of development, incandescent lamps are still being improved. Last year lamp engineers took a long look at something that had been conventional for many years, and decided they could improve it. This was the bulb shape. By making a section of the bulb cylindrical, the net area of the bulb was increased without changing either the maximum diameter or the length. This, plus an electrostatically deposited silica coating on the inner surface of the bulb, gives better diffusion of light and eliminates any "hot spot." The difference between this and the inside frosted bulb is startling when they are compared.

In addition to this new bulb, improvements have been made to three-light lamps. Coiled-coil filaments in the 50/-100/150 and 100/200/300 watt lamps, replacing single-coil filaments, has provided an approximate increase of eight percent in light output at each wattage level. Use of silica coating in these lamps also provides essentially glareless light. On both of these three-way lamps, the use of coiled-coil filaments permits reduction in bulb size. ■

"lost" light reduced

Glare is something streetlighting engineers strive mightily to eliminate in their luminaires. One reason, of course, is its annoyance factor to both pedestrians and drivers. More than that, however, it is usually an indication of "wasted" light that could be utilized to better advantage on the roadway. A new fluorescent street-lighting luminaire, called the Mainstreeter, effectively eliminates glare.

Lighting engineers took a new approach in this fluorescent luminaire. In the first place, they designed it to be mounted parallel to the curb, as contrasted to other luminaires that are mounted at right angles to the roadway. To achieve even light distribution from sidewalk to opposite curb, they first developed a new reflector, which in end view looks like two adjoining parabolas. Mounted in each of these parabolas, at the point determined to give the necessary light distribution, is a fluorescent tube. The prismatic refractor for this luminaire is equally unusual. One portion is essentially parallel to the roadway, and directs most of the light striking it in a downward spread, covering the near half of the roadway. The other portion lies at an angle to the roadway, and throws most of its light to the far half of the road.

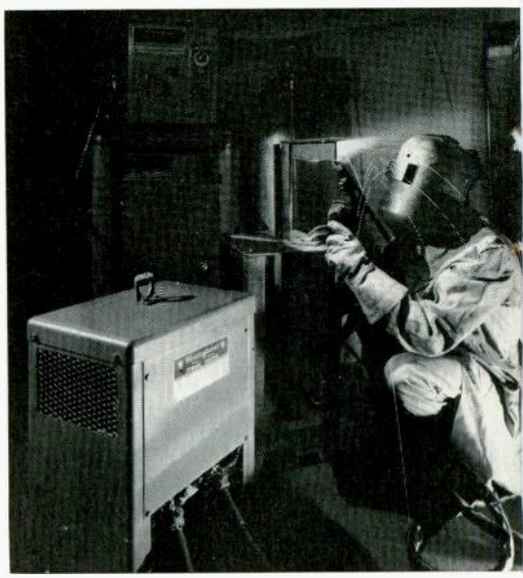
Control of stray light is effected by optical louvers on the refractor. Light that leaves the refractor in other than the desired direction is redirected downward to the roadway by these louvers. This effectively prevents glare.

The net result of these features is at least 50 percent higher utilization of light than any previous fluorescent luminaire.

This is the first fluorescent street-lighting luminaire with an optical system using prismatic control, or a refracting lens. The new luminaire was developed with cooperation of engineers of the Holophane Company. ■

Surfliner

Sometime in the future, flat, thin, electroluminescent panels may be used for interior lighting. Meanwhile, however, lighting engineers are steadily cut-



ting down the thickness of fluorescent fixtures. A new one, called the Surfliner, is but 3½ inches in depth, yet light control is not sacrificed.

The major part of the housings for these luminaires is molded of acrylic or polystyrene plastic. The unit is designed so that when mounted in lines, the end cap is not used. This, plus the interior arrangement of the fixture, provides a continuous line of light, as contrasted to most fixtures, which have at least a one-inch dark area between units.

The new unit is designed for both sleek appearance and convenience. The hinging and latch are invisible; the spring-mounted basket opens by pushing one side. The units are built for 2, 3, or 4 lamps, and for 4- and 8-foot lamps. ■

one-way lighting

Ultimately superhighways may be lighted along their entire length, rather than only at interchanges. Toward this end, lighting engineers have developed a unique new luminaire designed specifically for this purpose.

Lighting superhighways is a special problem. Overhead lighting that is directed straight down would cause an annoying and repetitive "flash" of light as the driver passed each pole; over a long stretch this might also have a hypnotic effect.

The new lighting system is designed to throw light along each lane in the direction the car is traveling. The luminaire designed to do this has sharp cutoff so that light does not shine in the opposite lane, which would be directly in the eyes of the oncoming motorist. A combination of reflector, lens, and a built-in "egg crate," accomplish accurate light throw and sharp beam cutoff.

The system is designed for use on superhighways built to Federal specifications, one of which requires a minimum 36-foot medial strip between lanes. On such highways, the luminaires can be designed to prevent glare to motorists in the opposite lane even on curves. While still in the development stage, this lighting system may well be the answer to turnpike lighting in the future. ■

find the ballast

Someone unfamiliar with a new mercury streetlighting luminaire would have trouble locating the ballast. It is designed right into the unit itself, and in such a way as to be completely inconspicuous. This has several advantages, among which are the elimination of separate mounting fixtures for the ballast and simpler installation.

The housing for this unit is of one piece die-cast aluminum, which not only provides sleek appearance, but exceptional mechanical strength. The entire optical system is sealed—including the socket opening—which reduces the necessity for cleaning and maintains light output. The built-in ballast is located in the "neck" of the luminaire, with a hinged access door at the bottom. Location of all elements is such that mounting adjustments, ballasts, capacitors, and wiring terminals all can be reached from one ladder position.

Much attention to appearance has been given this luminaire. The luminaire gives a sleek horizontal look, even though the optical system is tilted. The new unit, called the Silverliner (OV-25) is made in two versions, with or without built-in ballasts. ■

SEMICONDUCTORS AND ELECTRONICS

Germanium is well recognized for its use in transistors and rectifiers; but when given the "Midas Touch" and doped with gold, it becomes photoconductive and its ability to conduct electricity is changed as infrared radiation falls upon it. As a result, changes in the intensity of infrared radiation reaching the photoconductor are converted into changes in the electric current passing through the germanium material.

This new team of gold and germanium can detect infrared radiation less than one-twentieth of a billionth of a watt. The extreme sensitivity of the detector allows it to be used in homing missiles, astronomical studies, and other temperature measurement and control jobs.

In addition, this p-type gold-doped germanium photoconductive cell responds to the low-energy long wavelengths in the infrared spectrum. The device can sense wavelengths up to 10 microns, which corresponds roughly to the peak radiation at room temperature. But no other features are lost to gain this, as response is 10 times faster than any previously measured photoconductive detectors. In fact its response is so lightning fast, special laboratory apparatus had to be developed to test its speed. The apparatus, a mechanical light chopper, breaks infrared radiation into pulses only a few billionths of a second long. The pulses, reflected to the surface of the detector, show its time constant to be two-tenths of a millionth of a second.

Since the sensitivity and frequency response of a photoconductive infrared detector is increased at low temperatures, the detector is cooled to minus 320 de-

Left—By limiting weld current, the Dynamic Reactor permits any-position welding with the CO_2 process, limits weld penetration for light gauge metals, and permits use of larger, less costly wire.

Center—Versatility is the keynote of this ballast for mercury lighting. One tank design serves for pole-top, aerial, vault, or pole-base mounting. Adapters and different brackets convert the unit for different mountings. Another advantage is the versatility of termination methods. Adapters enable use of conduit connection, taping sleeves, stud terminal connection and other methods. The unit is enclosed in an aluminum tank, with the transformer potted in compound. Ratings range from units suitable for 175-watt mercury lamps to units for 1000-watt mercury lamps.

Right—Truck headlamps withstand ten times more shock than any previous truck lamps as a result of a new filament wire, called "M" wire. In this test, the truck headlamp was dropped 650 times per minute, yet continued to burn brightly. The new headlamp is designed for use in 12-volt truck systems.

grees F, by surrounding it with liquid nitrogen in a Dewar housing. ■

high-speed dynistors

Two years ago a hybrid semiconductor was developed—the germanium dynistor. This static device has the switching characteristics of a transistor and the power-handling capabilities of a rectifier. Its reverse and forward voltage-current characteristics are similar to a diode, except that when the rated voltage is exceeded in the reverse direction, the resistance breaks down, allowing the flow of large currents. Thus the dynistor is essentially an on-off switch that can be controlled by varying the value of the reverse voltage. The first applications of this device were in high-power ranges. Units were developed that, rated at 250 volts, could be operated with currents up to 10 amperes.

Now this device has found use as a low-power switch—particularly in computers. Three units have been developed that have breakdown voltages of 50 to 150 volts. These low-power (200 milliampere) units have a very useful feature. They can switch from one state to another in about 20 millimicroseconds. In computers, where millions of switching operations are required, any reduction in switching time amounts to a sizable saving over the course of a year. While read-in read-out time presently takes about 6 microseconds, germanium dynistors can cut this down to 0.6 microseconds. Engineers estimate that this drastic reduction puts computer developments three years ahead of schedule. ■

developments in electronic tubes

Military needs spur development in electronics. Many of these directly involve tubes. Space permits only a sampling of this year's developments.

"Match Box" Envelope—A new type of receiving tube envelope, dubbed the "match box" design, uses the same electrode structure as conventionally designed receiving tubes. But reliability improvements were realized because the tube stem is eliminated and all lead welds to the mount structure are in one plane, making the welds more accessible.

Basically, the new envelope consists of two "halves;" the preassembled electrode structure is merely placed between the halves, and the halves are glass welded together. The rectangular envelope shape permits greater flexibility for both tube designer and equipment designer. For example, the high-dimensional accuracy of the tube envelope and the protusions for locating the mica spacers permit the elimination of the mica serrations, thus reducing the possibility of loose particles and gas. Since the mount structure is locked within the envelope, microphonism and resistance to severe vibration and shock is greatly improved. The tube also lends itself to recessing or strapping onto the printed circuit board. Since the tube socket is eliminated, noise and circuit capacitance is reduced. Larger lead spacing is possible, which minimizes pick-up or feedback and allows simpler and more reliable soldering. Although the design has future commercial application, development efforts are presently concentrated on fulfilling military needs.

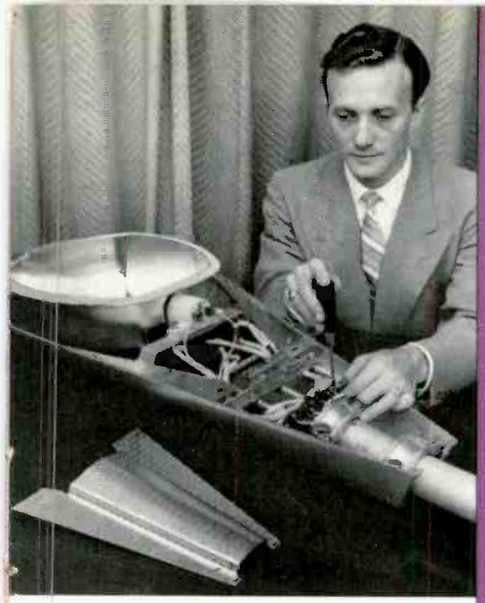
New Television Gun—A new "screen-grid amplifier" electron gun for all applications of high-definition pictures for tv and radar systems has been developed. For a standard 525-line tv picture, a drive voltage of only two to six volts is required, as compared to the 50 to 70 volts required by conventional guns. This low drive eliminates an amplifier stage from the cathode-ray tube circuit. Picture tubes and radar display tubes equipped with the new gun can be driven by transistors. A better total rendition of the pictures is made possible because an increased number of half tones can be reproduced by the cathode ray tube.

Slow-Scan Vidicon—A new small-size vidicon camera tube (WL-7290) designed for slow-speed scanning operations is most applicable where a narrow bandwidth signal is desired, and is obtained by a very slow scan. For example, the new tube is useful for transmitting high-resolution information over conventional audio circuits. In the ordinary vidicon, it is undesirable for the picture to remain on the storage surfaces for any appreciable length of time, since this would cause blurring or smearing of the image. The WL-7290, on the other hand, is able to store or "freeze" the image for several minutes, provided the surface is not scanned by the beam during this time. A high-quality picture, with 350-line resolution, can be held for two minutes.

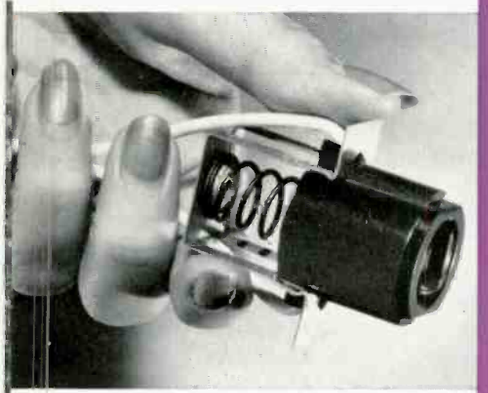
Rugged Image Orthicon—The sensitive image orthicon television camera tube has been considered a delicate device—but not so with a new ruggedized version (WL-7198) developed for military, industrial, and scientific applications where the tube might be subjected to extreme environmental conditions of shock, vibration, temperature, and humidity. The tube will operate through a range of vibration with 10 G's acceleration up to 500 cps. At 5 G's acceleration (50 to 500 cps), the tube shows horizontal resolution of at least 350 lines with only 0.03

This closeup of the new Mainstreeter fluorescent streetlighting luminaire shows the refractor. Note the prismatic louvers (top) that redirect "stray" light down to the road.

This new experimental luminaire is designed for lighting superhighways, with the light beam thrown along the road in the direction of traffic flow. Interior louvers plus lens are designed to provide sharp cutoff of light in other directions.

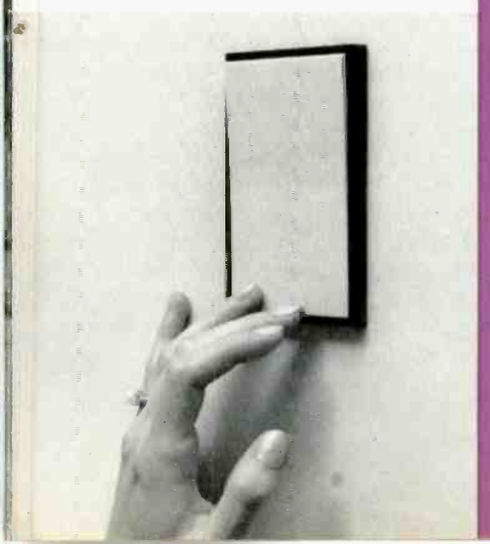


The ballast on this new mercury street-lighting luminaire is incorporated in the same housing.



Above—This new fluorescent lamp-holder can provide for three different lamp types—bi-pin, slimline, or recessed contact types. Three different plungers, with identical external configurations and mounting dimensions, fit interchangeably into one basic bracket.

Below—A new concept in light switches uses a plate actuator instead of the usual toggle handle. Lights are turned on or off at the tap of a finger tip, or the nudge of an elbow. The large actuator, which is, in essence, a moving wall plate within a frame, is easy to find; small movement and low actuating force make it easy to operate. Actuators for the switch may be molded of either opaque or transparent plastic. With different colored inserts behind a transparent plate, any decor may be matched, to suit the user. The switch, called the Fashion Plate, will be furnished in two ratings of 15 and 20 amperes, for use on 120/277 volt a-c circuits.



foot-candles illumination on the photocathode. Thirty G's shock does not impair subsequent tube performance. Although a rugged tube, the WL-7198 retains its sensitivity; at least 250 lines horizontal resolution can be obtained with only 0.0003 foot-candles illumination on the photocathode of the tube.

High Resolution Radar Picture Tube—A radar picture tube (5CEP11) has been introduced for use in radar and other military and industrial systems. The resolution has been greatly improved over that of any previous tube. The 5CEP11 produces 667 lines to the inch, or a scanning line only 0.0015 inch wide across the 5-inch faceplate. This is one-third the width of scanning lines produced by earlier similar tubes. In addition, the faceplate is optically flat and made of gray glass to increase contrast.

Tube With A Memory—A storage tube (WL-7228) for use in radar will store over 100 000 pieces of information. In a fraction of a second, information received by radar can be committed to the memory of the storage tube for long periods. When needed, information can be displayed visibly on a fluorescent screen long enough for the human observer to grasp. The tube contains three electron guns. One gun receives and writes information on the memory unit at a rate of over 200 miles per hour; a second gun wipes out the stored information, or any part of it, at will. The third gun enables the information to be brightly displayed on a screen. Although developed primarily for defense purposes, this new tube has peaceful applications. For example, it would be of use to airport tower operators, who could observe and record the course of approaching planes.

Flux Mapping Counter Tube—Thermal neutron flux mapping is made easier and faster with a new miniature fission counter tube (WL-7186). Readings can be taken in minutes as compared with hours in the activation method of plotting neutron flux levels. The WL-7186 counter tube is a small fission chamber, 0.5 inch long and 0.25 inch in diameter, with an integral rigid coaxial cable 4 feet long; however variations have been made in lengths up to 20 feet. Ionization pulses are produced in the nitrogen-argon atmosphere of the chamber by fission fragments that result when thermal neutrons strike a sensitive coating of uranium oxide, highly enriched with the U-235 isotope. The tube and cable are rugged in construction, and the fission counter operates in any position at temperatures up to 220 degrees F. Recent development work has extended this temperature to 500 degrees F for similar tubes. The exposed portions of the chamber and integral cable are made of stainless steel, permitting operation under water.

Ignitrons For Fusion Experiments—The high peak current conduction capabilities of ignitron tubes has been put to use in atomic fusion power experiments, conducted at the University of California Radiation Laboratory. A special version of Westinghouse 5550 ignitron is used to trigger the discharge of a capacitor bank, with currents ranging from 30 to 50 thousand amperes. The ignitron is also used to short circuit an inductive load. This combination of capacitors and conductors supplies the high instantaneous pulse currents needed in fusion experiments. Tube designers working closely with electronic engineers of the University of California Radiation Laboratory are experimenting with variations of the ignitron to improve voltage withstand ability before firing and to increase tube life. Variations include threaded anode connectors, epoxy coated anode seals to increase external voltage flashover values, and different ignitors and ignitor supporting structures. ■

high hi-fi

A new line of super-power high-fidelity amplifiers are "flat" from 5 cycles to 100 kc, with distortion of less than 2 percent. The amplifiers come in power ratings from 2 to 200 kw. These super-power amplifiers are being applied to a variety of jobs, primarily in the research fields. Typical examples are audio sound test chambers, ultrasonic work, sonar evaluation and research, and vibration and environmental testing of aircraft and missiles. A 200-kw amplifier built last year is the largest in the world for driving an environmental shaker system. ■

AVIATION AND MARINE

The first Westinghouse J-34 jet engine was produced in 1947. By mid-1958, the seventh model in the J-34 series received military approval. This latest model, the J34-WE-46, will power North American Aviation's new T2J Navy jet trainer.

The J-34, in various models, has logged some 2½ million flying hours. It has seen extended service in such applications as the Navy's F2H *Banshee* and the F3D *Skyknight* fighters, and has been used in such experimental concepts as the XF-85 *Goblin* parasite fighter, and XF2Y *Sea Dart* water-based fighter, and the X-3 high-speed research aircraft.

The J34-WE-46 engine is an axial-flow, fixed-exhaust-area, turbojet engine operational to an altitude of 45 000 feet. Sea-

level performance ratings at military operation are 3400 pounds thrust and 1.063 specific fuel consumption. The maximum dry weight of the engine is 1210 pounds.

The WE-46 version was designed to burn either of two primary jet fuels, JP-4 or JP-5. These fuels were developed by the armed forces to provide maximum jet engine performance at minimum cost. JP-5 is a kerosene-type fuel particularly suited to high-speed, high-altitude operation. The make-up of JP-4 ranges between JP-5 and aviation gasoline. By using an engine that burns either of these two regular jet engine fuels, the Navy can simplify its supply problems, especially during carrier-based operation.

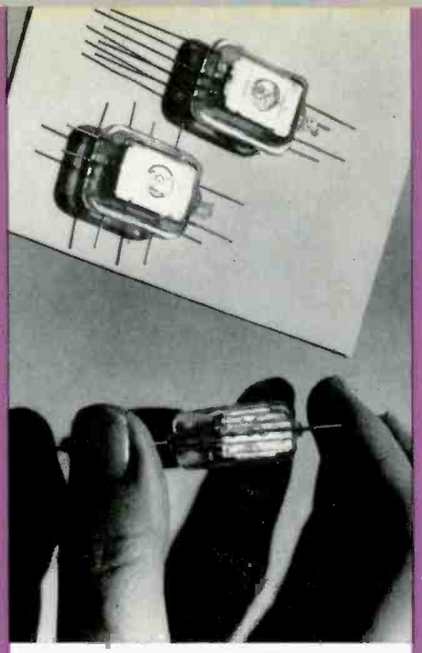
The initial engineering effort was applied to designing a new combustion chamber to handle the JP fuels. This program was later expanded to include an overall modernization of the J-34 engine. The engine went from drawing board to its first complete engine test in just one year; one month later, it completed a 150-hour endurance test. Six months later it successfully passed the official U.S. Navy qualification tests on both fuels.

The engine incorporates a new compressor, combustion chamber, fuel system and other modifications to permit use of the special jet-engine fuels. The compressor rotor was modernized from a one-piece aluminum forging in the earlier models to a multi-disc steel construction. In the previous model, lubricating oil was cooled with inlet air. In the WE-46 version, fuel, on its way from the tank to the combustors, cools the lubricant through a liquid-to-liquid cooler. The ignition system was changed from a low- to a high-energy system to give better air starting characteristics, and provide improved operation reliability. The new engine is equipped with an air turbine starter.

The fuel, lubrication, and electrical systems insure complete power modulation of the engine within its rated flight and altitude conditions by manipulation of a single power lever. ■

aircraft electrical systems improved

The aims of aircraft equipment designers are to simultaneously make their equipment: perform more functions, accomplish them more accurately and reliably, and yet make that same equipment smaller and lighter. The task is made even more difficult by the severe environmental conditions under which the equipment must operate. Yet designers seem to come up with new ideas to take care of a situation of ever-increasing complexity. For example, consider a few of this year's developments by the engineers who design aircraft electrical equipment.



New match-box receiving tube envelope design.

This new 200-milliampere Mobilex x-ray unit can be moved from room to room in a hospital to make radiographs of bedfast patients, without moving the patient from the bed. The unit is designed to provide maximum mobility and maneuverability with minimum effort. Two 10-inch diameter wheels are located at the unit's center of gravity to insure ease of rolling. Two 4-inch casters are used at the forward end, and a 3-inch caster at the rear, which enables the unit to be tilted slightly to clear door lintels and to enter elevators. All motions of the tubestand—vertical, rotational, and tubearm can be operated with finger-tip effort. To provide maximum x-ray picture quality, a milliampere-seconds timing device and an exposure assurance circuit are used. The latter is a sensing device that monitors line drop to deactivate the unit if the drop reduces kilovoltage to an unsatisfactory low level.

Alternator Control Loses Weight—Transistors have taken over the job of magnetic amplifiers and relays in a new control unit for aircraft alternators. The function of this control is to hold the a-c generator output to 115 volts plus or minus one volt, and to detect and protect the generator and its feeders from fault conditions such as excessive overloads, short circuits, or open circuits. The present control unit uses magnetic-amplifier circuitry and electromechanical relays for these functions. Each of these units weighs 14.5 pounds and occupies 730 cubic inches.

A newer design uses transistors, printed circuit boards, and new circuitry to accomplish the same functions in a fraction of the space. The transistorized unit (TACU) weighs but 7.5 pounds and occupies only 392 cubic inches. In performance, the transistor unit not only equals the performance of the previous control, but also has many new features to improve performance and reliability. Its first application will be on an advanced design of a high-speed jet bomber.

Transistors have also been put to work in a new voltage regulator (AVR-62), and here again they replace a magnetic-amplifier regulator, with attendant reduction in size and weight. In this case the reductions are about 60 percent in weight, and 65 percent in volume. The new regulator holds steady-state voltage to within plus or minus 2½ percent over a range of environmental temperatures from minus 55 to plus 120 degrees C. The speed of response to return system voltage to normal after disturbances from fault conditions is improved at least 50 percent.

The new regulator will be applied first in a system rated at 10 kva, 208/120 volts. Subsequent units will be applied to systems up to 90 kva.

Automatic Testing—As the control panels for aircraft electrical systems increase in complexity, their testing becomes a difficult and time-consuming process. To help this situation, engineers have come up with two new automatic test sets. One is a production device, which applies simulated faults and control signals to the control panel to check its reactions. A complete test of each unit is performed automatically by this set, to assure that it meets the stringent requirements imposed on it. The new production test set makes its test automatically in approximately five minutes, compared to about two hours for the previous manual testing. Also, the automatic tester performs its tests more accurately and reliably.

A similar device is now at work performing reliability tests. This test set puts

the control through tests similar to the production unit, but runs through repetitive cycles. This is designed to detect marginal components that operate initially but tend to fail early in the life span of the control unit. Each panel is cycled to subject it to as many of the control functions as it will perform in 2½ years when installed in an aircraft.

The records from these tests will be tabulated on an IBM system, enabling the data to serve several purposes conveniently. Among other things, records will help establish the reliability of components as well as complete electrical systems, and will provide a wealth of information to help designers build more reliable equipment in the future. ■

improvements in airborne components

Many of the developments for modern aircraft and missile systems are dependent upon improvements in component equipment. Some examples are:

Hydraulic Servo Valve—These valves are used in hydraulic drives such as antennas and autopilots, as a means for converting an electrical signal to a hydraulic signal. The immediate application of a newly designed Westinghouse valve is in a missile antenna. Pressure derivative feedback provides improved dynamic frequency response characteristics, yet gives the high steady-state pressure gain of the conventional flow control valve. This valve is designed to operate in a 1000-psi servo system. Another version of the pressure derivative feedback valve has been designed to operate in a 3000-psi servo system.

Digitally Programmed Analog Computer—A new airborne computer will be a hybrid of two basic computing techniques, digital and analog. The standard analog computer uses one element to perform a single function in a fixed-wired design; digital computers, on the other hand, use only one basic arithmetic unit, with some elements for adding, others for multiplying. Consequently, the digital computer has considerable flexibility, and need merely be programmed to handle all types of problems. Design engineers are now working on an analog computer that will also be programmed. The computer will accept inputs in analog form, which can be directed to a basic arithmetic unit that can add, multiply, etc. as instructed; the outputs are in analog form, ready for use in the system. Errors per operation are only about 1/10 percent, and the computer will operate in ambient temperatures from minus 55 to plus 100 degrees C. An immediate application for the new computer is in track-while-scan equipment where multiple targets are involved.

Memory System—A new magnetic-core memory system with extreme speed is being developed for a computer system that will be used in a target-sorting capacity for airborne operation. The memory cycle must be extremely fast, and the system must work in a high-temperature environment. In fact, the intended design will operate in an environment in excess of present magnetic-core limits. In computer language, the development is described as a linear-selection, coincident-write, random-access magnetic-core memory system. The memory has been separated into two parts—an instruction memory and an operand (the number that is being stored) memory. The operand memory consists of both data and constant words. Hence, the system will provide a means for storage of both instruction and data.

Clutter Navigation Computer—A computer that was originally developed for improving radar operation has also been made a navigational aid. In a moving aircraft, the radar signal frequency hitting the ground is changed due to Doppler effect, and shows up in the radar system as unwanted noise, or "clutter." Once the frequency of the clutter is determined, it can be filtered out, thereby improving radar reception. Hence, the computer described was originally developed for computing the ground speed component of velocity, which lies along the line of the radar antenna. The computer determined approximate ground speed from air speed, wind speed and direction, and trigonometry. This gives starting information, from which the radar can track, correct for wind data, and determine clutter frequency. Designers have, in effect, "closed the loop" by taking the clutter frequency determined by the computer and recomputing true ground speed from Doppler effect. Hence, the total system uses the airborne fire-control radar for both Doppler navigation and fire control.

Automatic Testing—The complexity of the modern missile is becoming fantastic. To aid in the myriad of tests that must be performed on a missile target seeker, a complete system of automatic and semi-automatic test stands have been developed. Component parts are checked in their preliminary stages to be sure that minimum and maximum tolerances are met; then as the equipment progresses, combined components are checked; a final stand tests the complete system. The test equipment saves time, eliminates human errors, increases reliability, and reduces cost. Any fault or error in the system can be quickly pinpointed. Each of the test stands have built-in self-test features to insure correct operation. The same equipment could also be used in overhaul centers and field locations. It would allow rapid checkout of missile readiness by unskilled personnel.

Another automatic tester has been developed for depot testing of the Aero 13-F fire-control computer. The test equipment automatically programs 47 test problems to the computer, monitors and evaluates the computer's solutions without any interpretation required by the operator. What the computer can accomplish in less than 10 minutes would take about 8 hours to do manually. ■

Installation of the new J34-WE-46 engine in T2J Navy jet trainer gets under way at the Westinghouse Flight Test Center, N.A.S. Olathe.

wind tunnel near completion

Sometime in mid-1959, the mammoth compressor blades of the propulsion wind tunnel's supersonic loop will be kicking up a storm—about 3700 mph worth. This will round out the Air Force Testing Facility at the Arnold Engineering Development Center at Tullahoma, Tennes-

see, the wind tunnel center of the Air Research and Development Command. The two loops, transonic and supersonic, can then subject missiles, airframes, and jet engines to air speeds from Mach 0.5 to Mach 4.9. Also, pressure in the tunnels can be changed from almost zero to 2.0 atmospheres absolute.

A drive consisting of four motors—totaling 216 000 hp—will power both loops. The drive can be split in the middle, providing power for both tunnels, or all four can be combined to drive either one.

The transonic tunnel was placed in operation in 1956; the supersonic compressor was installed last year and now awaits finishing touches to the tunnel. The supersonic loop is the big brother of the transonic loop in many ways—where the transonic compressor is a three-stage unit, the supersonic tunnel has 18 stages split into four rotors. Where the discharge temperature of the transonic compressor is 180 degrees F, its big brother will throw out air at more than 650 degrees F.

Since the larger blades will be under severe centrifugal and vibratory forces, an indication of superimposed vibratory stress is needed at all times. This is obviously a problem when the rotor is turning at 600 rpm. But engineers solved this with precision slip rings and brushes. Strain gauges installed on the rotor blades send electrical signals out through the slip rings, so blade stress can be indicated on cathode ray oscilloscopes. ■

wind tunnel gets new lease on life

As goes the speed of aircraft, so goes the speed of wind tunnels. And with the topping of speed records an every day occurrence, many wind tunnels reach obsolescence before old age. But with some major face-lifting, most can be rejuvenated and again put to useful work. The NASA's facility at Langley Field, Virginia has been so reworked from a subsonic to a transonic tunnel by replacing the old 8000-hp motor with a 20 000-hp drive and installing a new compressor.

In the process engineers added several interesting features. The tunnel is to operate in either air or Freon gas, allowing the Reynolds number of the model and full-scale design to be matched over a wide range. Because of the lower speed of sound in Freon gas, the compressor operates at lower speeds. The 20 000-hp wound-rotor motor was then designed for two speed ranges (235 and 470 rpm). This is accomplished by changing the number of poles of the motor—unique for this size. For driving Freon gas, the motor is operated up to 235 rpm using 28 poles, but in air, motor-operated switches reduce the number of poles to half this value, allowing the motor to run at a base speed up to 470 rpm. Over each of the speed ranges the speed is controlled with a liquid rheostat and regulated with an eddy-current brake. ■

high-temperature test facilities

Long before a missile is finally checked out on the launching pad, a critical test must be made. Can the structure withstand the searing frictional heat encountered in its escape and re-entry path? Because flight tests with models would be difficult as well as costly, engineers have brought this problem to earth.

Elevated temperature test facilities have been developed that apply heat to a full-sized missile to simulate its flight through space. And while the missile "cooks," various strength tests are made to determine the feasibility of a particular design.

As a prelude to the test, the desired function of temperature versus time is drawn on a graph with electrolytic ink. In the test, a curve follower then reads the graph and furnishes an electrical signal proportional to temperature at every instant. A bank of tungsten-filament lamps surrounding the missile then portion out radiant energy in accordance with this signal. The electrical power to the lamps is controlled with a computer-regulator. To assure that the correct temperature is maintained at the missile surface, thermocouples feed a temperature signal to the computer-regulator.

During flight, the temperature is not the same at all points on the surface of the missile; therefore, in the test arrangement a total of 15 regulators and power channels provide independent regulation of up to 15 areas of the surface. To give an idea of the response of the system, the temperature can be made to rise at 1000 degrees F per second to a total of 2650 degrees F. The tungsten filament lamps can develop 7500 kw of power for 15 minutes and 30 000 kw for short bursts. This high-temperature system is now being used to test the Air Force Titan intercontinental ballistic missile at the Martin Company Denver Division. ■

digitalized test data

Obtaining useful test data consists fundamentally of three steps; recording the variable quantity, converting it into some meaningful form, and displaying the result in some logical manner. Test engineers working with aviation gas turbines have assembled a combination of units into a test arrangement in which data is automatically taken, converted to a digital number, and typed on a form for easy inspection. The information is also punched on a tape for a permanent reproducible record.

The jet engine to be tested is placed in the test cell and the test apparatus assembled in the normal manner. A total of 60 imputs can be measured by the apparatus—air flows, temperatures, fuel consumption, engine vibration, and engine speed to name a few.

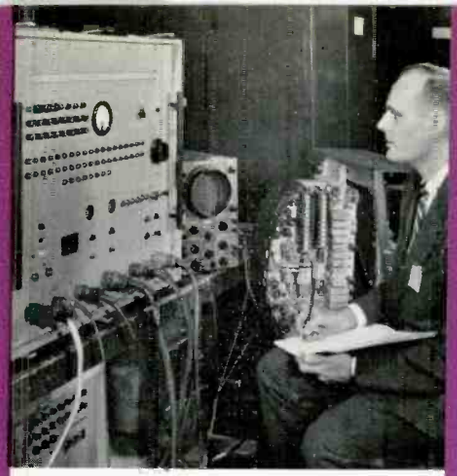
Metallurgical engineers at the Westinghouse aviation gas turbine plant have developed similar equipment for taking data from some 30 high-temperature, stress-rupture furnaces. They have further provided an extremely economical system by using a centralized system for measuring and recording data from each of the 30 furnaces. An inexpensive magnetic amplifier control programs the heating cycle for each furnace. The centralized digital voltmeter periodically takes a reading directly from the specimen in each furnace and feeds it to a converter, where the information is translated for an electric typewriter. Readings are taken every 15 minutes, 24 hours per day, 7 days per week. The equipment can be left completely unattended, since it has a built-in quality control feature. It analyzes its own readings, and if a reading does not seem correct prints the questioned reading in red. If five consecutive questionable readings are obtained, standby equipment is automatically inserted. Likewise, in case of a typewriter key jam or other equipment malfunction, the equipment is turned off. ■

DB and DH—for the Navy

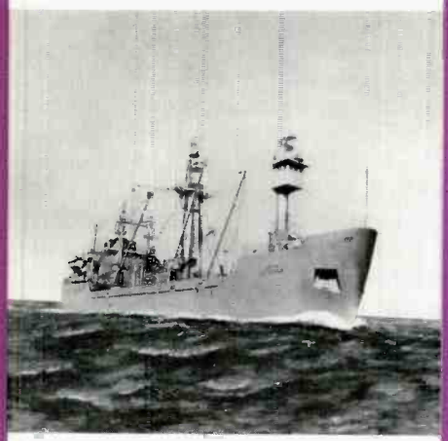
A whole line of low-voltage air circuit breakers have been developed for Navy use. Primarily an extension of the commercial DB line, these Navy breakers have been designed to resist additional shock and vibration that might be incurred during their life aboard ship. The normal current-carrying capacity ranges from 600 to 4000 amperes, with interrupting ratings from 40 000 to 100 000 amperes. The breakers are arranged in a new drawout design in a removable frame, which is built into a Navy switchboard.

One of the first applications of the new breaker line will be in the nuclear carrier and cruiser being built by the Navy.

A new 2300-volt breaker has been developed for the Navy for shipboard use. This is a new voltage class for shipboard distribution systems. Previously, even on the largest vessels, 440-volt distribution systems were used. However, some of the



Engineer takes test data from an automatic Computer Test Set.



The USNS *Eltanin*, a cross between a cargo ship and ice breaker, has already proven herself in Arctic maneuvers. Built by Avondale Marine Ways, Inc., at New Orleans, the ship is propelled by a diesel-electric variable-voltage system. Each of the two 1350-shp, double armature d-c propulsion motors is directly connected to one of the twin propellers.

A new search radar developed for the Navy departs from previous radar designs in that it is crystal controlled, thereby achieving extremely high stability. Also, instead of the usual rectangular pulse, a shaped pulse has been designed to decrease the required bandwidth for operation; this allows the high-power system to work in crowded environments without interfering with other electronic devices. To simplify testing and maintenance, the necessary testing equipment is built into the unit.

contemplated carriers are so large, and will use power in such large blocks, that the low-voltage system may bow to a higher voltage to reduce the size and weight of various electrical apparatus.

The new breaker, and extension of the commercial DH design, is going through strict "Navy exams," which include special tests much more rigorous than required for the "land lubber" variety. These include special shock tests, interrupting tests, calibration tests, and switching tests. For example, the breaker must interrupt its continuous current rating (2000 amperes) 1000 times and yet hold trip calibrations with strict limits. It will interrupt 55 000 amperes. ■

reliable torpedoes

The probability that an anti-submarine torpedo will operate correctly must be high, lest the submarine be in the position of Wyatt Earp with a misfire. New anti-submarine torpedoes must have a probability of 95 percent, which is extremely high for the highly complicated equipment involved.

To achieve this high reliability in torpedoes, some 30 percent of the initial torpedo contract money is going into reliability programs. A Westinghouse engineering reliability group sample tests all purchased parts and a significant number of production assembly samples. One notable difference lies in their test philosophy—they test everything to failure, be it by temperature, vibration, or voltage. Another objective group of engineers evaluates the various designs of other engineering departments and makes recommendations or rejections. The torpedo reliability program is the most extensive reliability program of any within the company. ■

military communications

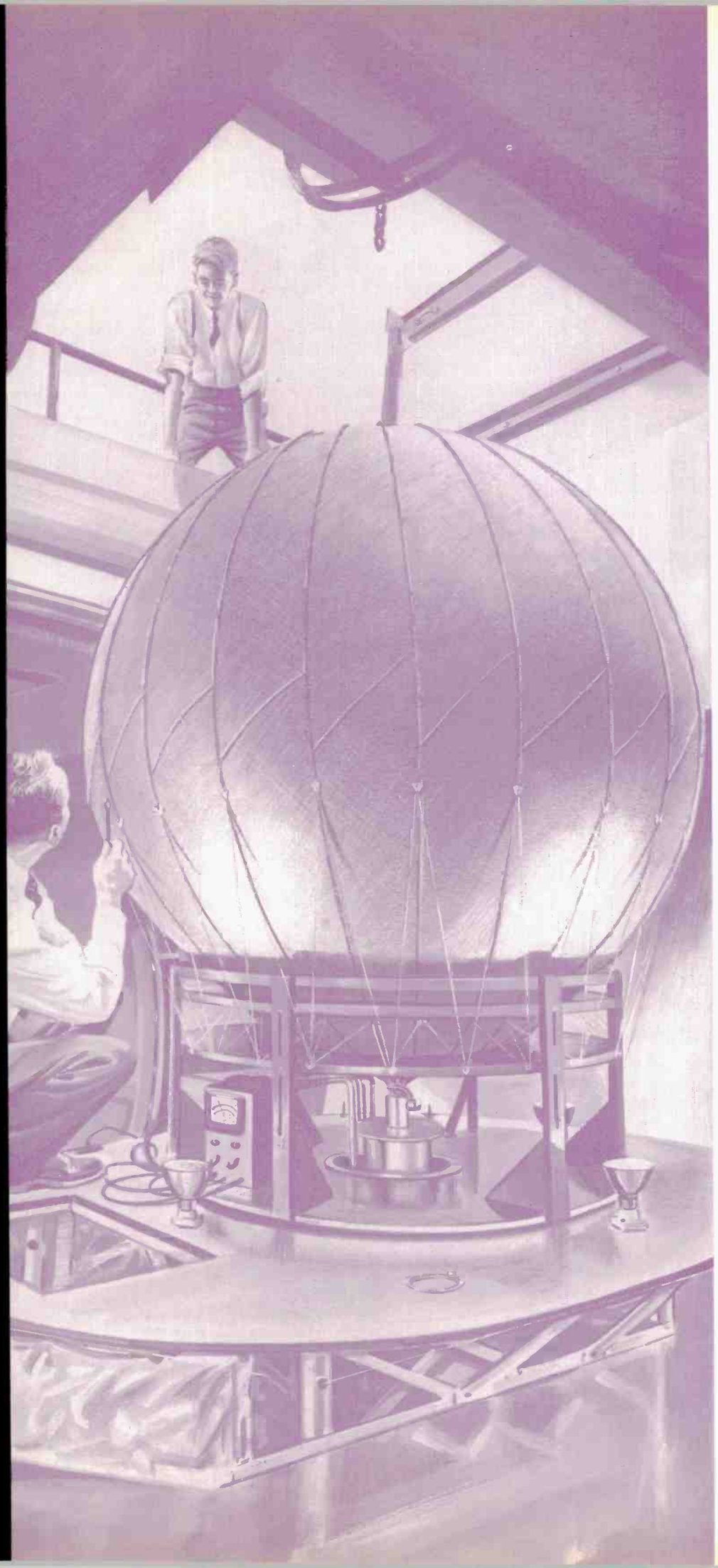
Many military situations exist where extremely limited-range communication is desirable; for example, in-flight refueling of aircraft or for convoy control. To obtain such a secure communication device, communication engineers are experimenting with a device that will transmit by means of an induction field, rather than the conventional radiated field. This is equivalent to using a transformer, but pulling the windings far apart. An all-transistor device, about the size of a handi-talkie, has been developed with a loop antenna that can be built into a field jacket. Tests have obtained distances up to 200 feet, and means are being considered for increasing this range from two to five times.

Scatter Communications—Scatter communications, the method of beaming a high-powered microwave signal into the air and picking up the "scattered" signal many miles away, has progressed from trial test links to tactical radio communications equipment. Under an Air Force contract, Westinghouse will build radio communications equipment light enough to be airlifted by helicopter and capable of transmitting and receiving 48 voice conversations simultaneously. Most of the circuitry and techniques for the new equipment have already been proven in more than a year's operation of a 100-mile test link in Canada. The complete units will weigh 2300 pounds and are packaged in weatherproof shelters measuring six feet wide, six feet high, and eight feet long. They can be placed in operation in about one hour after placement in a tactical area. The equipment is fm and operates at 4500–5000 mc. The equipment can also be used at reduced power for conventional line-of-sight microwave relay systems. For these shorter ranges, 240 channels can be handled with minor modifications. ■

remote controls for radar and missiles

A militarized version of industrial Visicode supervisory control equipment, normally used for such tasks as remote control of electric utility substations, hydro stations, or oil pumping stations, is giving an assist to the U.S. Air Force Continental Air Defense System. One element of the defense system consists of a ring of radar stations around the periphery of the United States. To obtain complete coverage, it has been necessary to plan on hundreds of unmanned "gap-filler" radar sites, which act as satellites to the principal radar stations. These sites feed radar and other vital information to the main radar station via telephone circuits. The control-monitoring equipment will aid in remote operation of these gap-filler sites from the main radar stations.

Supervisory control equipment will also aid in the remote control and indication of the guided-missile test range that extends from the launching site at the Patrick Air Force Base in Florida to Puerto Rico, some 1500 miles distant. The supervisory control equipment controls the ground radar and radio stations that guide, track, and record test data for the missiles. These control stations are located on various islands along the test range. The supervisory control operates on frequency multiplexed carrier channels over a submarine cable. The control and indication equipment operates by means of binary coded pulses with self-checking features to insure accuracy. ■



Since the initial "breakthrough" in electroluminescence several years ago, research scientists have been enthusiastically delving into every aspect of the phenomenon. What they are finding out is bringing electroluminescence ever closer to wide application.

One interesting aspect explored last year is the effect of phosphor particle size on the characteristics of electroluminescent panels. Fine particles lead to a faster increase of brightness with increasing voltage, give brighter emission at high voltage. Importantly, fine particles also give a higher efficiency. They can also be more easily incorporated into very thin cells. Coarse particles, on the other hand, give brighter emission at low voltages. By taking advantage of these different characteristics, cells can be tailor-made for different requirements.

Unusual possibilities are also created by the development of thin transparent phosphor films. These films, about one ten-thousandth inch thick, give off light when excited by cathode rays, ultraviolet light, or electric fields. Such films excited by cathode rays can be used wherever high resolution is required or where the surrounding light level is high and the trace on a normal tube would be invisible. Films excited by electric fields can be used where particularly low voltage excitation is required or where transparency of the emitting area is required, such as a case in which both transmitted and emitted light contain information.

Some of the effects caused by combinations of a-c, d-c, and radiation (ultraviolet or blue) are startling. For example, the combination of a-c and d-c voltages on certain phosphor layers results in d-c control of a-c light emission, and the brightness obtained with both voltages is hundreds of times greater than with either voltage alone. This combination, among other things, permits detection of very small a-c voltages.

In a somewhat similar manner, a combination of radiation and electric fields on the same phosphor layer results in radiation control of light emission; with both radiation and field applied, the brightness can be many times greater than with either one. This effect might be useful in light "amplifiers." Importantly these combination effects can be achieved in large area layers using a phosphor already available in large quantities.

Many strange and unusual aspects of electroluminescence are being discovered, and many lack a complete theoretical explanation. For example, the original cells made by Destriau usually used a phosphor containing considerable zinc oxide.

Later Westinghouse scientists found that they could make a better cell without this material, and reasoned the "bad actor" was oxygen. This theory was borne out by subsequent experiments.

Despite the many questions still unanswered, the technology of electroluminescence has advanced sufficiently to allow some practical applications. One product made last year was a map board for map makers, which consisted of an electroluminescent panel that could be plugged into either 110-volt circuits or powered from a car battery. Another product is a digital display system. Many others are in late stages of development. ■

aluminum-iron alloys

Although the present supply of nickel is adequate to meet most immediate requirements, materials engineers are trying to develop substitute alloys in view of the metal's increased use as a base for high-temperature alloys. Most of the effort is aimed at eliminating the use of nickel in noncritical applications where its use is dictated by custom, such as in resistance-heating elements.

As a result, a class of Hirox aluminum-iron alloys has been developed that can probably replace the nickel-base heating elements common in many consumer and industrial products.

The initial requirements imposed on the substitute alloy were many. It had to have high-electrical resistivity and good oxidation resistance—and, of course, be free of nickel. In addition, related requirements of high strength and thermal stability had to be met.

After reviewing property data on a number of alloy systems, metallurgists arrived at a class of iron compounds with about 10 percent aluminum and 10 percent chromium. These materials were known to have good oxidation resistance; however, they had serious shortcomings in fabricability, joinability, and room-temperature ductility. The development program was then aimed at modifying the structure and properties of these materials through compositional and processing techniques.

The properties of the new alloys were even better than expected. The Hirox alloys appear to have better oxidation resistance, higher electrical resistivity, and at the same time have a useful service temperature up to 2300 degrees F. And, since they are ductile at room temperature, they can easily be drawn into the convenient form of wire.

These alloys may have other applications. For example, thanks to their high-oxidation resistance they might also be used as "skin" on high-speed missiles, or as a substitute alloy in nuclear reactor fuel-element cladding. ■

the digital computer in reactor design

The large digital computer has become one of the reactor designer's basic tools. For example, the physics performance of a drawing-board core now can be calculated by computer. Still, the need for larger and faster machines and better coding systems is ever present.

In earlier stages of the nuclear art, methods of predicting mathematically the lifetime characteristics and behavior of core designs were crude. The core had to be built and tested—an expensive but necessary process.

As more and more core configurations were built and tested, mathematically predictable patterns began to emerge. Digital computer codes were built on these patterns; these were capable, to a limited extent, of predicting how a similar core configuration, not yet built, might behave. Each new core yielded more information, which, when studied, led to refinements of the initial codes. Conversely, a large program on the development of neutron diffusion theory was embarked upon, written into codes, and then tested for validity and accuracy by comparing theoretical results with the actual behavior of specifically designed cores.

The ultimate aim of this step-by-step process is to develop a set of digital-computer codes that will yield all information needed on a given core design without building a test core.

The prediction of fuel depletion over the life of a reactor core is one of extreme complexity, requiring literally thousands of individual calculations. The basic problem of fuel depletion is further complicated by a number of side effects that affect reactor physics calculations.

In the early stages of design, when a wide range of reactor parameters are explored, one-dimensional codes are often adequate. A reactor, however, is a three-dimensional entity. Thus the next step was to design a two-dimensional code. The jump from one to two dimensions in physics calculations increases the complexity, coding time, and computer operating time by many orders of magnitude. Months of preparation are required to code some two-dimensional problems.

Until recently, three-dimensional effects were being synthesized by combining a number of two-dimensional solutions with a one-dimensional solution. The reactor core is divided into "slices," each of which is considered a two-dimensional problem. These are solved separately. The two-dimensional solutions are then "stacked" mathematically in the one-dimensional problem to present an approximate three-dimensional picture.

Complex as this three-dimensional synthesis is, it cannot predict with sufficient accuracy all that happens within the core throughout its life. These results must be combined with others to factor into the basic design problem such additional physical effects as local inhomogeneities in the core, neutron escape, thermal utilization, temperature distribution, and core hot spots.

Three-dimensional codes for these lifetime calculations are now being used. However they are limited in scope because of existing computer abilities.

Despite present limitations, reactor computational methods have been remarkably successful. When properly applied to water-moderated reactors, reactivities within 1 or 2 percent of the measured values can be obtained.

Although the use of prototype cores and critical experiments still cannot be completely avoided, the computer program has already advanced to the stage where designers are relying heavily on machine predictions of lifetime behavior of reactors at full power. ■

thick polyethylene plate—by extrusion

Thin sheets of polyethylene are often made by an extrusion process. Until recently, however, thick polyethylene plate could be made only by compression molding. A radically new extrusion process now permits the continuous production of heavy polyethylene plate up to 1½ inches thick and 48 inches wide. The two prime advantages: a six-fold increase in production rate, and a guaranteed void-free plate.

In addition to its use as a neutron radiation shielding, the new plate is particularly suited to structural uses, where its chemical inertness, thick cross-section, stiffness, and unlimited length can be used to advantage. This new plate can also be used as a dielectric barrier, where heat is not a factor.

The new material can be fabricated with conventional woodworking tools and techniques. It can be fastened by adhesives, nailed, or bolted. Polyethylene plate can also be welded. Its potential uses depend largely on the imagination of designers. ■

shaking of atoms

Scientists have discovered a new way to probe into the complicated interior

structure of matter—by shaking its atoms back and forth up to 20 million times a second. The technique, known as "nuclear magnetic resonance acoustic absorption," is a major advance in methods for studying the structure of crystalline matter. Nuclear magnetic resonance acoustic absorption (NMRAA) takes advantage of the fact that the nuclei of atoms resemble tiny spinning magnets. These nuclear magnets have north and south magnetic poles that tend to line up parallel with one another when placed between the poles of a magnet. The shaking supplies enough energy to affect the spinning nuclear magnets, thereby upsetting the atoms' magnetic balance. The unbalance is detected through tiny electrical signals that show the interaction between the atomic nuclei and the electrons swarming around them. This electronic look inside the atoms of crystalline matter reveals the crystal's internal structure, and leads to a better understanding of the forces holding the crystal together.

The technique is based upon a phenomenon called nuclear magnetic resonance (NMR), which has been known for more than a decade. NMR is used to study the structure of molecules, to make chemical analyses, to study chemical processes, and to obtain basic scientific data on certain types of crystals. However, NMR has limitations. This technique does not work for metals and semiconductor crystals simply because the pulsating magnetic field used cannot penetrate these materials and tip over their nuclei. These substances act as a shield against the pulsating magnetic field, just as a steel building cuts radio reception by shielding a radio receiver from radio waves.

Fortunately this shield can be penetrated. If a crystal is set into rapid vibration, magnetic and electric fields are created inside it. These internal fields interact with the nuclei in the crystal in much the same manner as an externally applied field.

When the motion matches exactly the frequency of wobble of the nuclear magnets, the nuclei behave exactly as they do when a pulsating external magnetic field is applied to them. This nuclear shaking is done with high-frequency sound waves from a quartz crystal bonded to the crystal under study.

The objective in these experiments was to verify experimentally a theory that predicted this acoustic resonance in nuclei. However, from the results obtained, this new technique appears to provide a useful new tool. ■

red hot motor

A "red hot" electric motor has operated continuously over extended periods at ambient temperature of nearly 1000 degrees F. The motor is believed to be the first to have operated in the thousand-degree range for any appreciable time without some form of artificial cooling; it has run for more than 100 hours sealed in an oven at 950 degrees F.

To put the motor insulation to its severest test, the motor bearings were placed outside the oven and cooled with forced air. Such versions of the red hot motor have run continuously at 950 degrees for as long as 1000 hours.

The motor was designed to test the performance of a new system of electrical insulation for electrical equipment required to operate at very high temperatures, such as those encountered in the supersonic flight of jet planes, missiles, rockets, and other high-speed aircraft.

In the red hot motor, there are four basic insulation components: phase insulation, slot insulation, wire insulation, and the potting impregnating compound.

The phase and slot insulation is flexible sheet material that consists of glass cloth and large mica flakes bonded with phosphate. The wire is insulated by covering it with glass fiber and then impregnating with a suspension of powdered mica in a phosphate solution. When so insulated, the wire is flexible and then can be wound into motors in a conventional manner. After winding, the motor is impregnated and potted with a liquid slurry consisting of a phosphate solution, Wollastonite, silica, and other chemically reactive materials. The potted motor is dried out to remove free moisture and then pyrolyzed above 600 degrees F to develop the best properties.

The new insulation has been tested for performance on a series of experimental motors. First tests were conducted on a five-horsepower motor operating at 110 volts. To raise the motor temperature high enough to challenge the insulation, heating strips were placed around the motor frame. The whole motor then was covered with a thick coating of asbestos. In this early version the motor bearings were exposed to air and cooled by forcing additional air through them.

The motor ran at full speed under no-load conditions for more than 1000 hours at temperatures well above the melting point of metals such as lead and zinc. After the tests were stopped, no deterioration of the insulation was found.

Following these initial tests, the Westinghouse scientists constructed several versions of the red hot motor. These were smaller in size and used standard motor frames. Special high-temperature bearings allowed the motors, including their bearings, to operate continuously in the nearly 1000-degree heat.

Copper wire could not be used to wind these experimental motors, because at such temperatures the metal soon oxidizes and becomes useless as an electrical conductor. Among the most successful motors were those wound with wire of pure silver. The insulation also has been tested in solenoid coils, in small transformers, and in other devices.

The new inorganic insulation has been prepared experimentally in a number of forms suitable for wide variety of uses. These include: insulated wire, flexible sheet insulation, and laminated materials. These insulating materials are easily prepared on conventional equipment with low-cost raw materials. Only minor changes from conventional methods are necessary for processing of the components into the complete insulation system. The thermal life of all the insulating materials up to temperatures of 950 degrees F is considered almost indefinite.

While some problems remain in perfecting these new insulating materials and in adapting them to practical use, the major problems in designing a very

NMRAA—In the small metal box between the poles of this large electromagnet, scientists vibrate the atoms of a crystal up to 20 million times per second to study the structure of crystal matter (story at left).

high temperature inorganic insulation have been largely solved. Such insulation is of particular interest because of its potential applications in the red hot electrical equipment demanded by supersonic flight. ■

taping harmonic strains

Turbine designers are continually plagued with potentially destructive vibrating forces in discs, blades, and diaphragms. Turbine parts must be mechanically designed to prevent them from literally shaking themselves to pieces.

Aviation gas turbine engineers have come up with a method for determining vibratory stresses and frequency deviation from a datum of the various individual turbine components, and automatically plotting a curve of these values versus engine speed or other parameter such as air flow. Where two or three months often were required to completely analyze strain-gauge data from a new turbine or compressor, the job now can be done in less than two weeks.

Prior to the development of the new method, strain gauge analysis involved a tedious process of manually measuring instantaneous magnitudes and counting frequency content from the strain-gauge signal displayed on a high-speed oscillograph trace. The method was time consuming and limited to the measurement of frequencies below 500 cycles; and further, determining true amplitude stress values of individual components was extremely difficult because of phase beating of the variable involved.

In the new method, the strain gauge signal is recorded directly on magnetic tape, as the engine is operated over its full speed range. The tape is then analyzed to determine the various frequency components. By means of spectrum filters, each frequency component is detected and recorded as a pulsating d-c signal. The plotter chart position is controlled by another signal on the tape that corresponds to engine speed (or other engine parameters), so that the result is a display of amplitude stress values versus engine speed. In a similar manner, frequency is also recorded as a function of engine speed. As a result, engineers are getting more reliable information, more of it, and over a much wider frequency spectrum. ■

objects cause sonar noise

Research scientists have had the first detailed look at the billions of "somethings" in the sea that are believed to cause the noise that jams sonar systems.

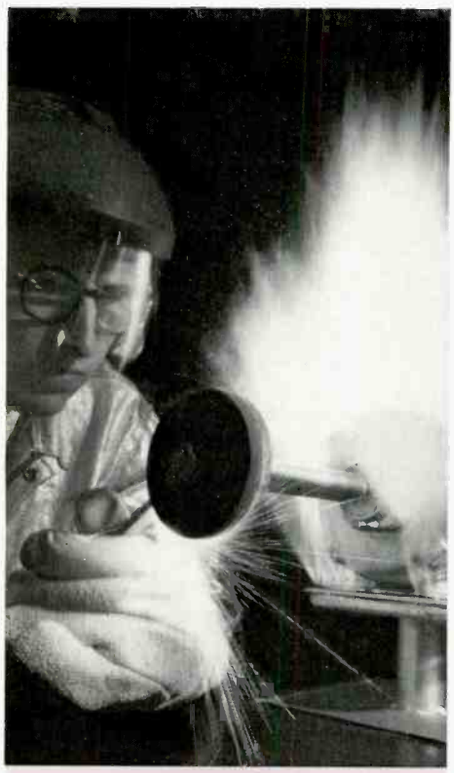
The look, an electronic one, was obtained aboard a Navy submarine in the Gulf Stream off the coast of Florida. Using short bursts of ultrahigh-frequency sound waves, the sea was probed to pinpoint individual underwater scatterers of sonar signals.

Collectively, these individual scatterers affect a sonar signal much as droplets of fog disperse and reflect the beam from an automobile headlight. They produce a confusing jumble of unresolved echoes, or noise, that limits the range of sonar signals and interferes with their clear reception.

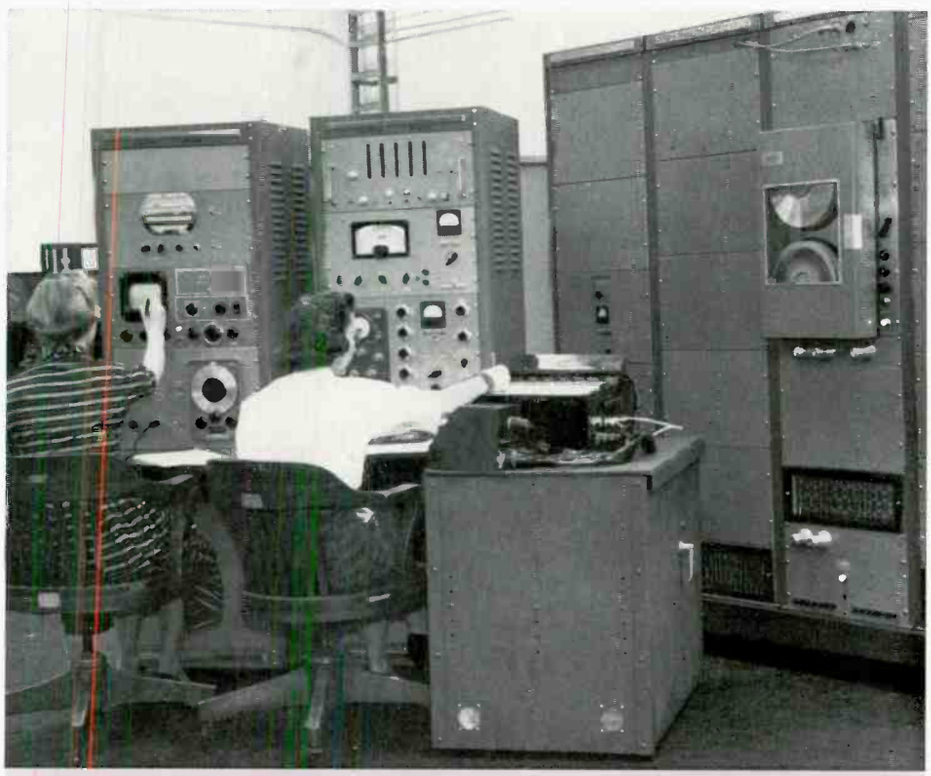
Therefore, in addition to the desired signal, the sonar receiver sees a continuous distracting assortment of indistinguishable echoes called reverberation. The object of the research was to study the nature and mechanism of this so-called volume reverberation.

Previous reverberation studies have employed comparatively broad pulses of ultrasonic energy. The Westinghouse experiments used ultrasonic waves with a frequency of 60 000 cycles per second, roughly four times the frequency of the upper limit of human hearing. These waves were broken into pulses less than half a thousandth of a second long, reoccurring at a rate of 80 pulses per second.

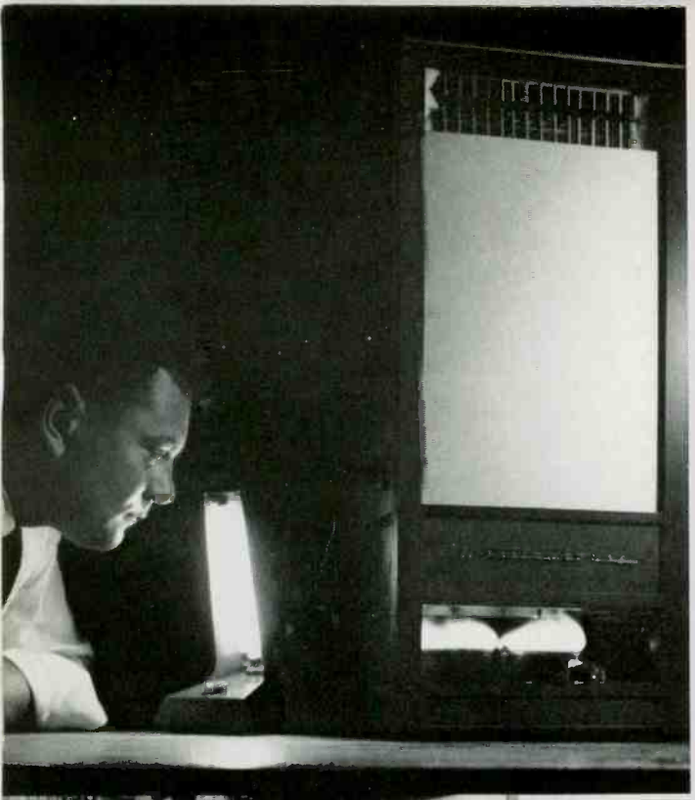
When these high-frequency, narrow pulses were beamed into the water, the results were quite unexpected. The con-

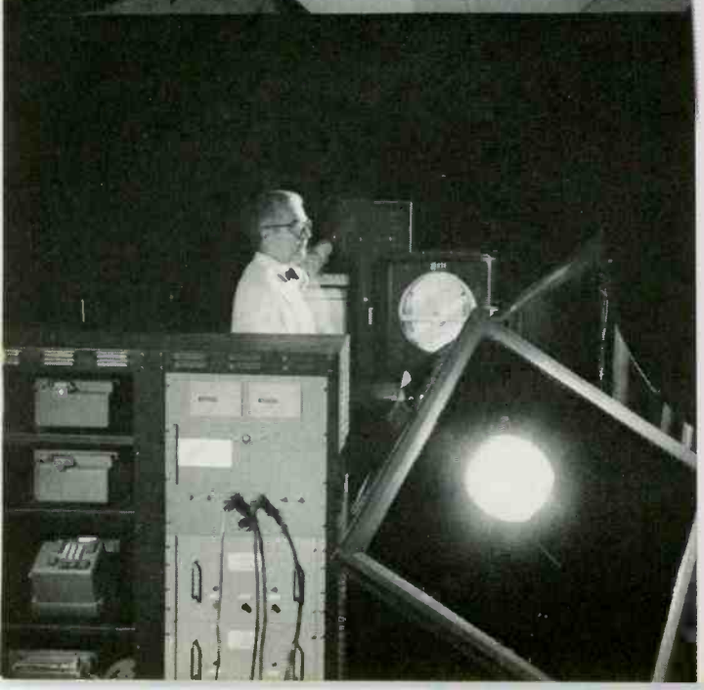


Hot Motor—Even in the searing heat from jets of burning gas, this experimental motor performs efficiently enough to do useful work, such as this grinding job (story at left).



Taping Strains—Equipment used by gas turbine designers for analyzing test data. Tape-recorded strain gauge data is analyzed and displayed as amplitude stress values versus engine speed. Complete analysis of strain-gauge data from a new turbine or compressor takes less than two weeks (story above).





***Left*—Thermoelectricity**—Thermoelectric power generation has long been an exciting scientific challenge. Recently, Westinghouse scientists discovered a large number of compounds in a previously unexplored class of solid-state thermoelectric materials that appear to make feasible the interchange of heat and electricity at the elevated temperatures encountered in standard methods of power generation. The experimental thermoelectric generator (at left) delivers ten watts of electric power. The generator was first demonstrated at a conference on thermoelectricity sponsored by the U.S. Naval Research Laboratory, where it powered a public address system.

***Center*—Cleaning With Sound**—The kitchen sink may be going ultrasonic. The same kind of ultrasonic sound waves used in underwater systems for detecting enemy submarines may soon be doing cleaning tasks for the housewife. The photo shows a full-scale experimental sink. Such new applications of ultrasonics are made possible by the development of a new and improved ultrasonic transducer. A radical new design has resulted in a transducer that is twice as efficient and considerably more compact than any existing units of comparable power. A number of Westinghouse manufacturing operations using ultrasonics have been made practical because of the new transducer. These include: electroplating aluminum bus bars with silver, cleaning printed circuitry boards for television and radio receivers, and decontaminating pieces of nuclear apparatus. In one typical application, the required manufacturing operations have been reduced from 12 steps to 3, and the time required from 30 minutes to 2.5.

***Bottom*—Automatic Photometer**—Taking photometric readings of a streetlighting luminaire normally takes two technicians about four hours, or a total of eight man-hours. Calculation of the light values and distribution, and plotting of curves takes another 25 to 35 hours. Now, using the automatic photometer (shown below) plus a digital computer, the readings can be taken and recorded by one man in an hour, and all calculations and curve plotting done in 13 minutes. The system automatically takes light readings at preselected points in the light beam. Programming of the photometer is accomplished by two tape readers.

Readout of information is in the form of punched tape. The tape is then run through a converter, and the information punched on cards. These cards are then fed into a digital computer to accomplish the necessary calculations. From this computer comes not only calculated values, but also a completely plotted illumination distribution curve. As far as is known, this is the first automatic photometer ever built. The present unit is designed for mercury and incandescent streetlighting units; engineers are now working on a similar arrangement for fluorescent luminaires.

tinuous jumble of sonar noise broke down into separate, distinct echoes. These distinct echoes proved the existence of discrete objects in the sea as the source of reverberation. And because these objects were distinct, their distribution and size could be plotted.

The experimental apparatus was installed aboard the submarine USS *Sea Poacher*. The transmitting and receiving transducers were mounted on the bow of the submarine and the associated electronic equipment was placed in the forward torpedo room. The signals received from the undersea scatterers were tape recorded and later analyzed in the laboratory.

Experimental data was collected during runs of the submarine at various depths and speeds. Depths ranged from 30 feet to 380 feet below the surface.

To measure the motion of the underwater scatterers themselves, one trial was a hovering operation in which the submarine remained nearly motionless. Another trial, to compare underwater and surface scattering, was a surfacing operation from a depth of 35 feet.

About six times as many scatterers were found at 80 feet as at 380 feet, but the acoustical size of the 380-foot scatterers was about three times larger. Acoustical size is a measure of the ability of an object to scatter sound waves and is not necessarily a measure of its actual physical size. But translated into terms of physical size, if these objects were bubbles of air they would, on the average, be the size of a pinhead.

Some scatterers remained motionless in the probing sonar beam, apparently moving forward at the same rate as the submarine followed them. In the hovering operation, the scatterers were observed to move with speeds up to one-tenth knot.

Such data leads to the belief that at least some of these individual scatterers under the sea are forms of animal life capable of motion. Theories as to their exact nature mention such varied creatures as fish, shrimp, squid, and a host of small organisms barely visible to the naked eye. But even strictly physical effects in the water may be responsible. Whatever these objects may be, they can now be electronically pinpointed. The next step is to attempt to take a visual look at them.

The underwater studies which led to the trackdown of the sound scatterers were carried out under the auspices of the Bureau of Ordnance, U.S. Navy and the Office of Naval Research, and were conducted by Westinghouse scientists. ■

SOLAR POWER IN SPACE

solar "sail" for space travel

The cheapest, simplest and lightest means of propulsion for man's exploration of space may involve a device used on earth for at least 3500 years. The device: A sail. Not a wind-powered sail, but a "solar sail" made of aluminum foil or lightweight plastic material no more than one ten-thousandth of an inch thick; it would use the energy of the sun to propel the space craft.

The solar sailboat would have to be launched from the earth by conventional rocket power. However, once in orbit, the rocket would be discarded and a huge, parachute-shaped sail could be unfurled and attached by shroud lines to a gondola carrying the payload and crew.

The solar sail has a significant and substantial advantage even before the space vehicle leaves its launching pad on the earth. For example, to send a one-ton load to Mars by chemical rocket, nine tones of payload and fuel would have to be shot up to a satellite station. With the sail, only one ton need be shot up because the solar sail needs to carry no rocket fuel.

In operation, the space ship using a solar sail would work like this: The ship would first be shot up from the surface of the earth by conventional rocket to an altitude of about 1000 miles, where it would circle the earth in a satellite orbit. Then the sail would be opened to receive the sun's energy. This energy would cause the orbit to become larger and larger until the space ship escaped the earth's gravitational grip to become a solar satellite spiraling around the sun.

By turning the mainsail—or possibly hoisting an auxiliary sail—this constant source of power could be used to control easily the direction of the space vehicle and thus reduce the serious problem of guidance in space. Space guidance would be a particular problem for rocket-powered vessels, which would have to use up precious fuel to be at an exact point in space at a precise time. But if the solar ship by miscalculation should miss on the first try, the sail will always provide the necessary propulsive force for another try. ■

for the man on the moon

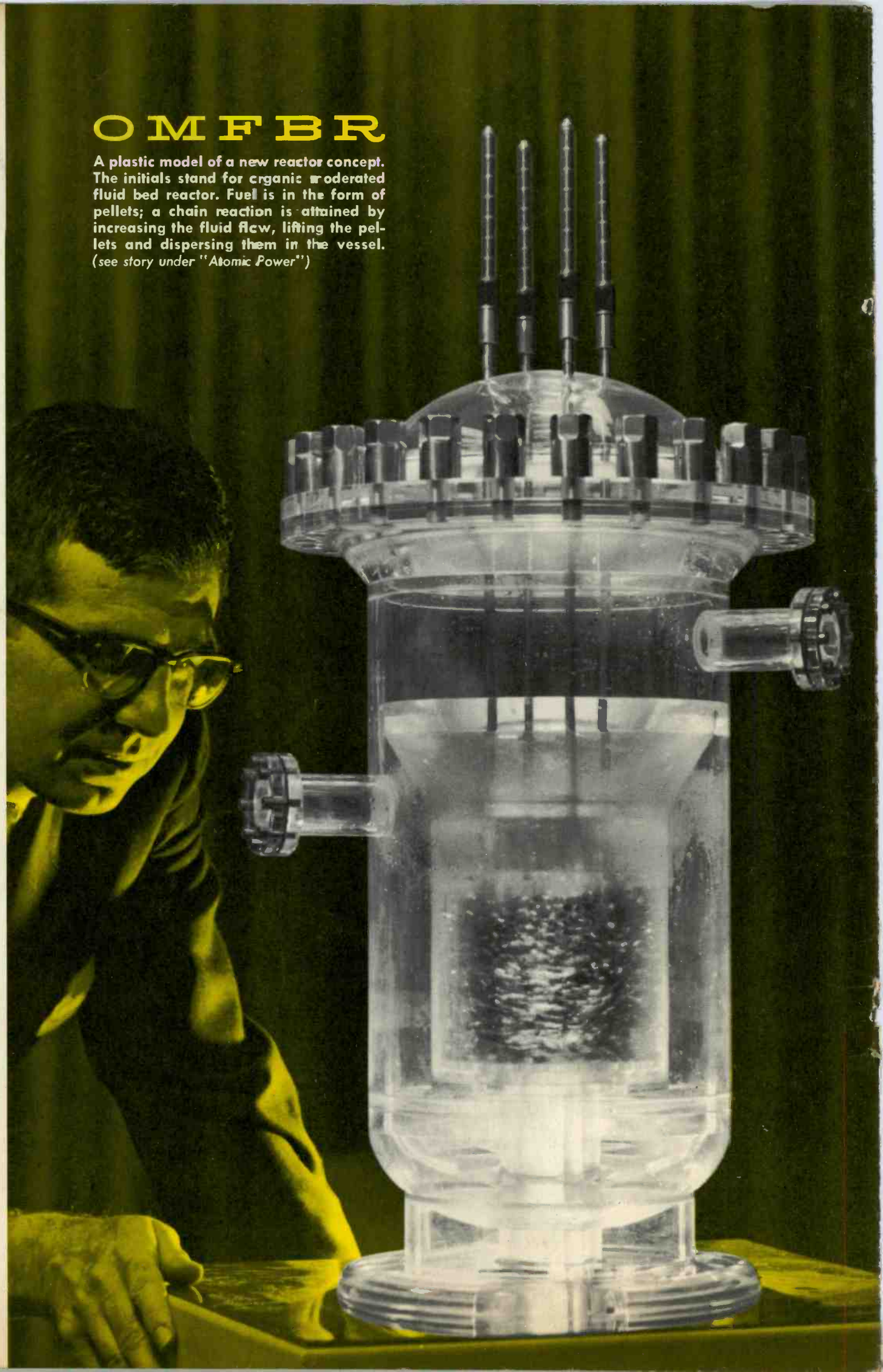
Although man has yet to reach the moon, the Westinghouse Astronautics Institute is busily investigating ways to make his lunar stay comfortable. The lack of atmosphere on the moon creates many disadvantages, but it also provides a few major advantages. One is the feasibility of a high-power electric generator using photoelectric processes.

Although the theory of photoelectricity has been known for many years, it has never been put to high power use because photo generation requires a vacuum, which would be costly to achieve on a large scale under atmospheric conditions, and subject to destruction. However, on the moon's surface, where vacuum is free, photoelectric generation becomes a natural for converting solar energy directly to electric power. Since the sun at zenith pours about 6000 kilowatts per acre on the moon's surface, the sun becomes an impressive source of power.

The basic principle of photoelectric conversion is simple: radiation impinging upon a metallic surface will extract electrons if the quantum energy exceeds the work function of the surface. If a collecting device in the form of a metallic grid is placed facing the emitting surface, the electrons emitted will strike the collector and generate a voltage. Closing the circuit between the emitter and the collector produces a current. Since the voltage generated by a single cell is relatively low, several cells could be connected in series.

Basic components of the actual power station would consist of wire mesh and a chemically coated plastic. Giant sheets of a thin plastic material could be stretched and supported over several acres of the moon's surface. Coated on these sheets would be an extremely thin layer (about one micron thick) of a photosensitive material. A thin wire mesh would then be placed parallel to, but slightly separated from the plastic sheet and insulated from it. The photoelectric generator would then be ready to produce electric power. Such a device would have long life since even relatively large meteorites hitting it would merely destroy a portion of the photo-converting surface, with a consequent relatively small reduction in power output.

An obvious prerequisite for the generation of power is a low internal impedance. Photoelectric cells normally have an internal impedance of about one megohm, and thus would be impractical. Work done at the Westinghouse Astronautics Institute and by electronic tube engineers have produced advanced structures that promise internal impedances of about 0.1 ohm, with even lower values foreseeable. Although in early experiments efficiencies of only 0.1 percent have been achieved, insight gained into the phenomenon now shows good promise for generators with up to 25 percent conversion efficiency. Achievement of this figure would mean power yields of about 1500 kw per acre when the photosurface is exposed to the sun at zenith. ■



OMFBR

A plastic model of a new reactor concept. The initials stand for organic moderated fluid bed reactor. Fuel is in the form of pellets; a chain reaction is attained by increasing the fluid flow, lifting the pellets and dispersing them in the vessel. *(see story under "Atomic Power")*