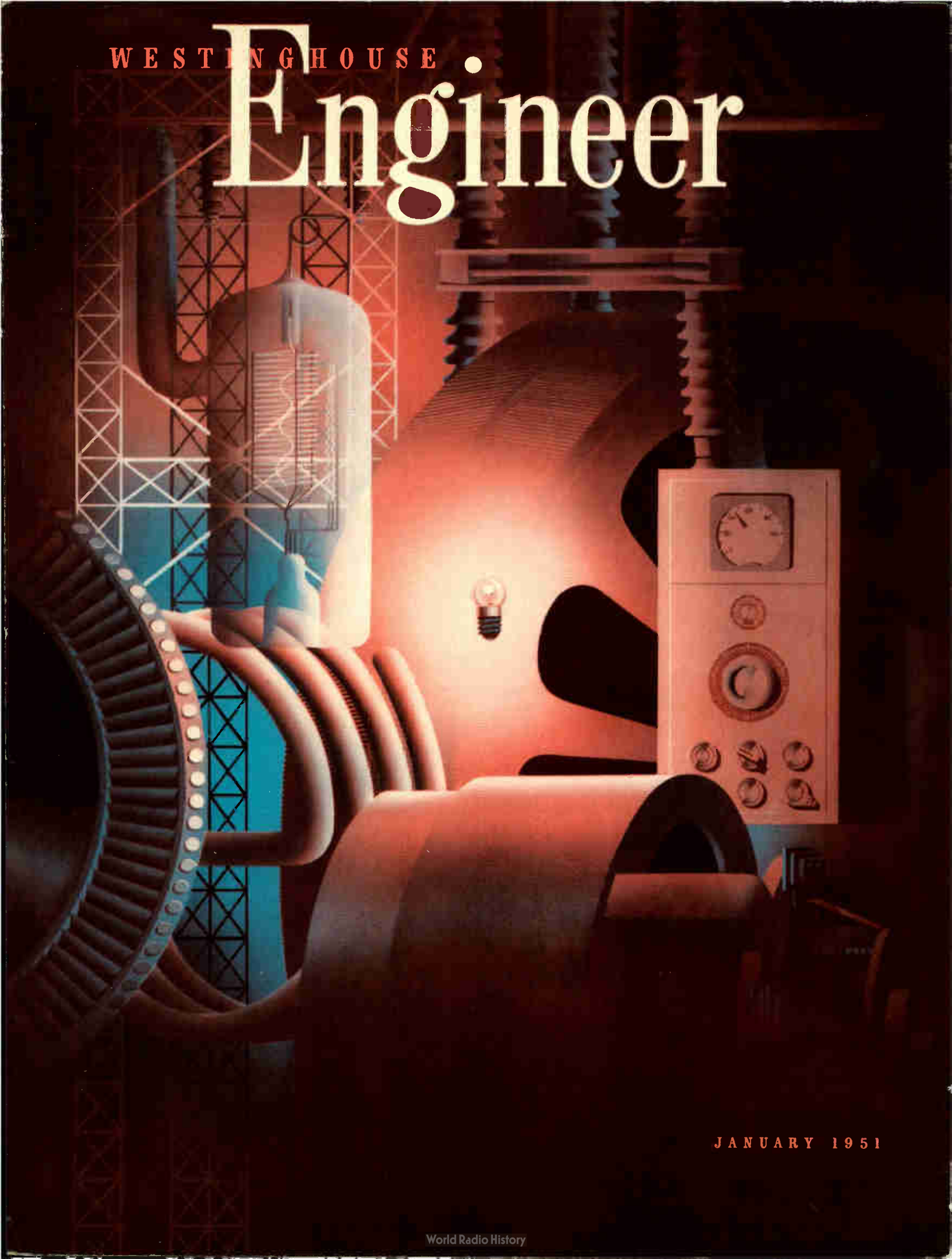

Engineering Progress If...

Just 30 years ago the Westinghouse Company began publishing an annual summary of accomplishments of its research and engineering departments. That 1920 edition spoke with pride of a 60 000-kw steam-generating unit, a 32 500-kva waterwheel generator, and seven 16 667-kva transformers for a 220-kv line. Circuit breakers had interrupted 600 000 kva on a 13.2-kv circuit. The electrical equipment for the locomotives of a d-c electrification were spoken of as being "well-nigh perfect." The battleship "Tennessee" with a 60 000-hp turbine-electric propulsion plant had been given trials, and diesel-electric drive had been applied to two pleasure yachts and one merchant vessel.

Each year since the appearance of the 1920 issue, interesting in retrospect, a new one has been prepared recounting technical developments of importance to industry. Regardless of industrial boom or depression, peace or war, there is, each year, an interesting and valuable assortment of technical accomplishments. Almost always they include new materials, improved basic machines for industry and new uses of those and older machines, occasionally some basically new principle, and always the outcome of important research. Never does any material, machine, or device actually reach an ultimate state of development—although at the time it is difficult to see how further improvement is possible.

The present edition runs true to form. Mention is made in text and pictures of some 150 diverse items of technical progress. However, it is far from complete. As many more items have been crowded out by lack of space. As always, they cover a variety of kinds of development in an equally wide variety of fields.

We have new records for size. High-speed turbine generators have reached 150 000 kva, circuit breakers have interrupted 10 000 000 kva. Some long-standing good ideas seem to have "turned the corner," like the rectifier locomotive and the series capacitor for transmission lines. There is a good crop of new materials, such as Thermalastic insulation for central-station generators, several new plastics for sealing electronic components from moisture and for providing a tough coating for coils and similar devices, an oxygen-inhibited oil for transformers, and a new finish for distribution transformers that is far more resistant to salt and corrosive atmospheres. One young device—the magnetic amplifier—has risen to new heights, and at least one new device, the microsyn, has appeared and holds promise of a bright future. Devices that increase the usefulness of electricity in the home have been genuinely improved. An experimental heat pump that draws upon the outside air for heat or cooling, as the season demands, is undergoing trials.

This seems to spell a story of solid accomplishment that is of value to industry generally. It suggests a healthy condition of engineering ingenuity and progress that augurs well for the industrial future of our country. And it does—up to a point.

Unfortunately dark clouds are appearing to cast shadows on this cheerful scene. They have to do with serious obstacles that impede the creation of basic new materials and products. Mostly these arise from restrictive regulations, uncertain patent protection, and a system of profit limitation that drains incentive from the large, more costly, but also more valuable programs for development of new materials and products.

The patent system has been one of the strengths of this country. Under it there has been assurance that, if risk were taken and success achieved, there would be opportunity for recovery of investment and for profit. A patent system is not just a set of rules but the legal interpretation of them. The trend of court decisions has been to lessen opportunity of reward for risk taken. There have, fortunately, been some hopeful signs in recent months that this trend may be halted.

As to a major development of, say, a new high-temperature alloy for jet engines or gas turbines, three things must be taken into account. Such a development is costly, perhaps a million dollars. It requires time, five years or more. Also, there is no guarantee that the venture will succeed; the chances are from five to ten to one that it won't. This requires that there must be good assurance of corresponding recovery of initial development investments on those that do pan out. To bring a major development to commercial suitability requires the potentialities of more than normal profits.

Profits from a development run a tortuous course. Where military contracts are involved, price redetermination and renegotiation, the Vinson-Trammell Act, and similar profit-limiting legislation may scale down the returns because of the difficulty of demonstrating the costs incurred in the effort. This is particularly important at a time like the present when the proportion of industry's business with the government is high. In addition, profits from all developments are subject to a high corporation income tax (42 percent in 1950; higher in 1951). The result is that for the future the possible rewards of development success are not great enough for the high order of risk taken. The profit-limitation philosophy to a large extent assumes that all ventures are successful. It does not take adequate account of the cost of the many more that fail.

Any tendencies toward weakening patent protection for successful ventures, or disregarding the high initial costs of product development and the risks involved, are dangerous things. They remove the incentive for pushing forward, which is one foundation of our industrial might.

The record of past years in general and, in particular, the last one—as touched on in this issue—demonstrates the continuing ingenuity of scientists and engineers, the virility of modern engineering so long as stockholders are justified in supplying money to back up their dreams. If preserved, if allowed to flourish in a favorable atmosphere, imaginative, courageous, venturesome technology will continue to enrich our land. It will ensure a healthy industry that is instantly ready to shift from peacetime to national-defense effort when needed. But it must have an encouraging, not a discouraging, environment.

WESTINGHOUSE Engineer

VOLUME ELEVEN JANUARY, 1951 NUMBER ONE

On the Side

In the past we have written, in these pages, of the multitude of elements that make up the electrical industry and of the various degrees of engineering that go into making the industry's products—from gigantic generators to smallest flashlight bulbs. Dick Marsh, our cover artist, has aptly expressed this concept of industry.

• • •

Only four years ago we mentioned in this column that Westinghouse had begun work on four of the largest motors ever built, the 65 000-hp units for irrigation pumping at Grand Coulee Dam. Preliminary work has been started on an even larger motor. Two motors, in fact, which are substantially larger and more powerful than these pump motors, are to drive a giant wind tunnel at the nation's Arnold Engineering Development Center to be built at Tullahoma, Tennessee. Westinghouse will build and install the electrical and mechanical equipment for the wind tunnel, which will include the largest rotating machine ever built.

• • •

Several months ago a large power transformer—a 95 000-kva, FOA unit—while in shipment to the customer was accidentally rammed into a bridge abutment. During the subsequent inspection back at the Sharon Works, customer and Company transformer engineers found that because of the excellent characteristics of the shell-form design (form-fit tank) there was almost no damage to the transformer iron and coils. Although considerable work was required to repair the tank and auxiliaries, basically the unit was sound; it was repaired and placed in service within a few weeks.

In This Issue—*Engineering Highlights of 1950*

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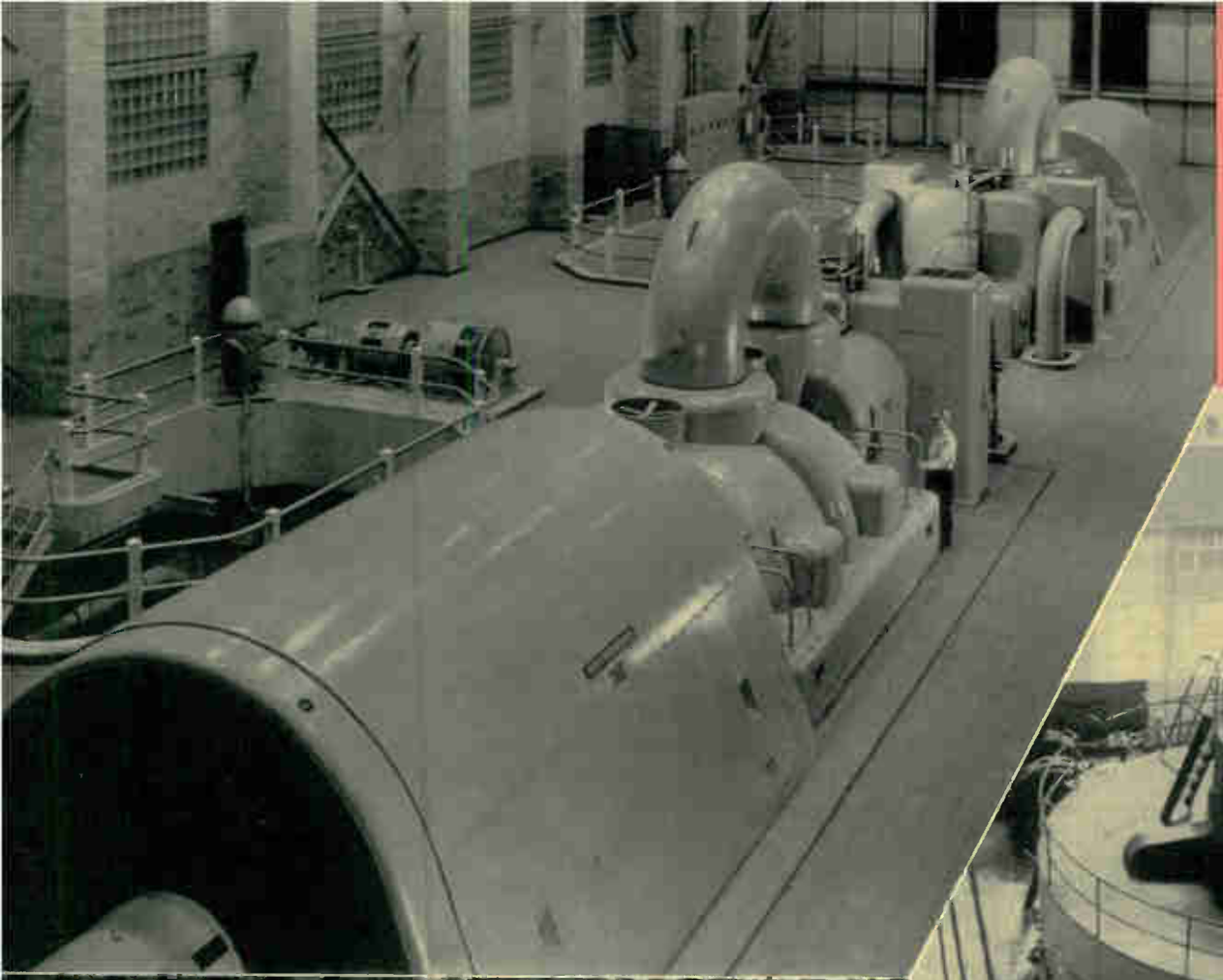
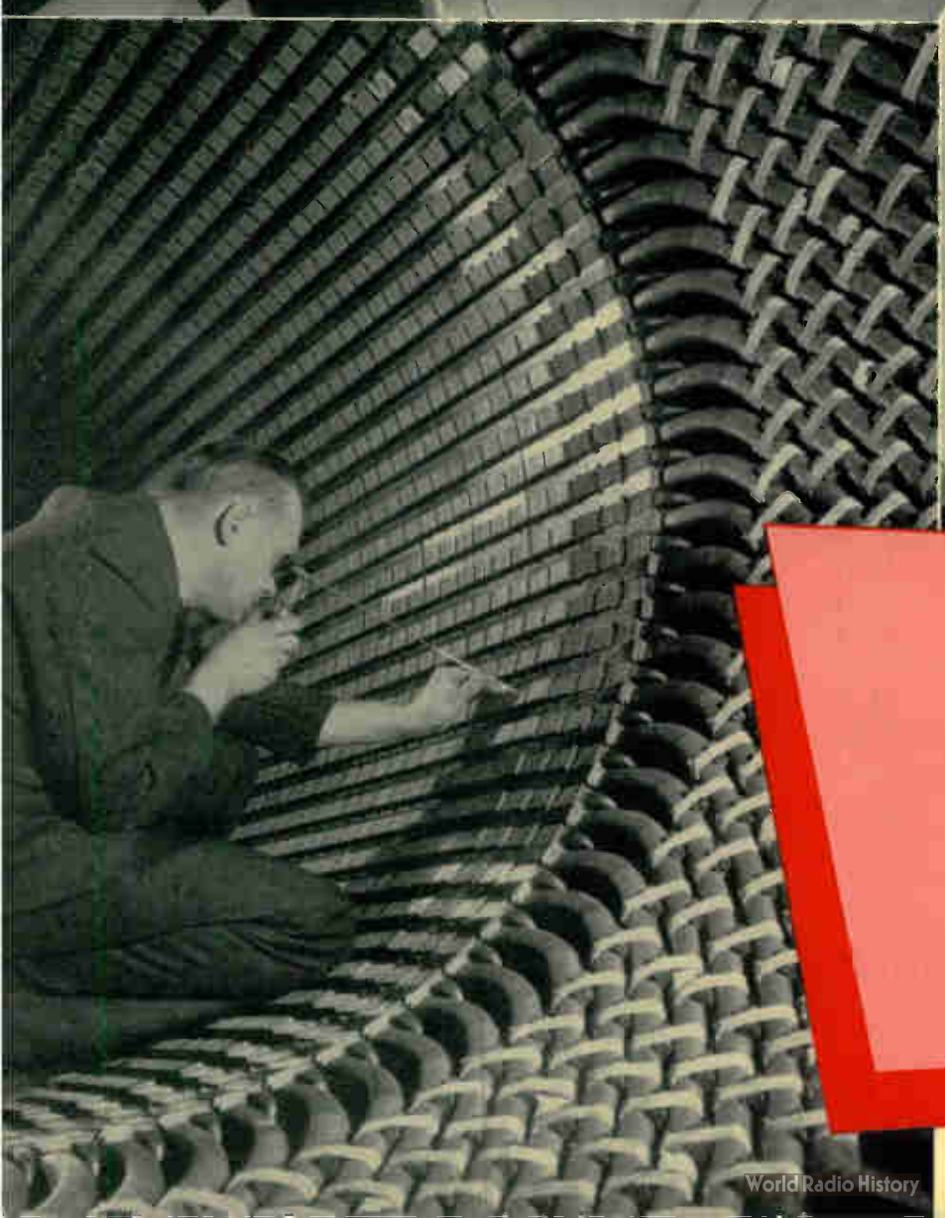
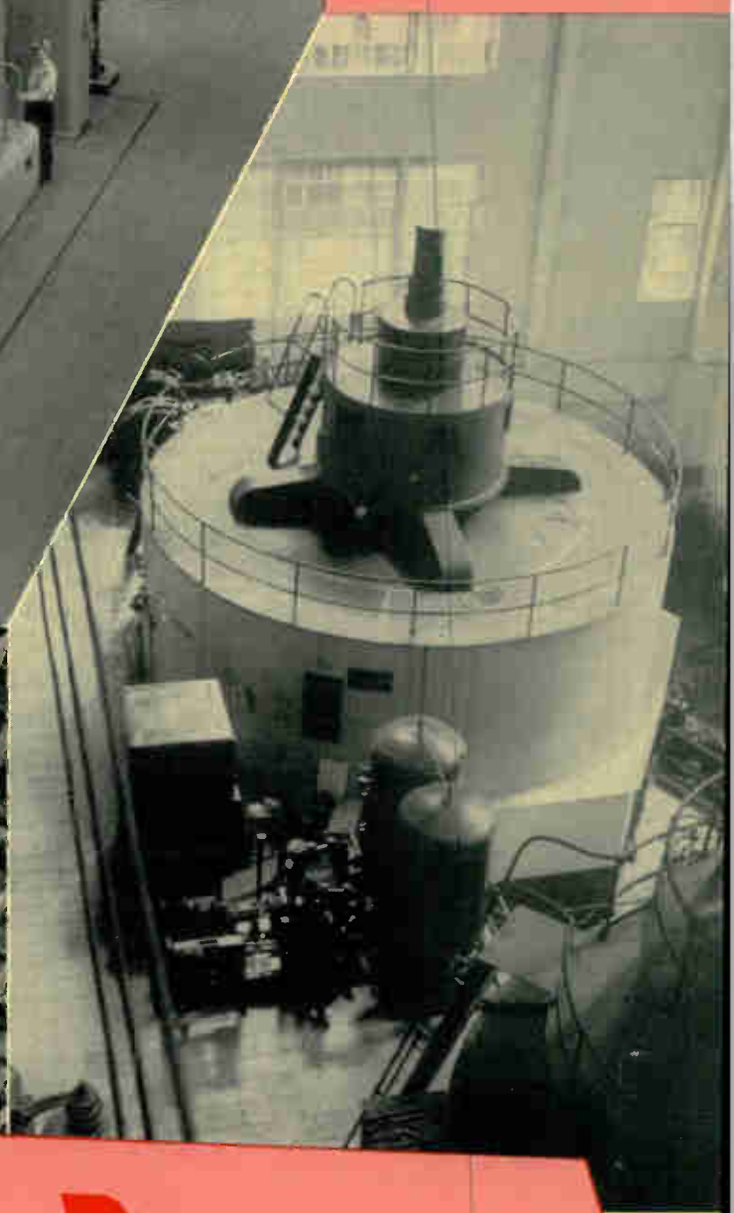


An 80 000-kw generating unit recently installed in Mitchell Station, West Penn Power Co.

Lower left—Use of cystoscope to determine the condition of turbine-generator insulation.

Below—When Big Creek No. 3 powerhouse, Southern California Edison Co., was built 22 years ago, foundations were poured for another 28 000-kva unit. That space was filled last year—with one of 35 000 kva.





Power Plants

More Generation, Fewer Btu's

THE TWO-PRONGED drive of the power companies to increase greatly the generating capacity and to do it with fewer Btu's per kilowatt continues at an accelerated pace. On the one hand, the demand for more power seems to be without end, on top of which looms the growing need resulting from the nation's preparation for a war status. On the other hand, fuel costs are climbing steadily.

One result has been twofold: more units of very large size and an increase in the size of the largest single-shaft capacities. Just three years ago these pages told of reaching 100 000-kw capability in a single-shaft, 3600-rpm machine. Now the Westinghouse Company has built or is building 37 units of this capacity, or larger. Of these, eleven are for 125 000-kw capability and four are for 150 000 kw. Larger ones can be expected.

The Steam End—Reheat is being widely used in the quest for every possible Btu. The first of the modern machines equipped for reheat is the 65 000-kw unit installed by the Boston Edison Company at its Edgar Station and placed in service in August, 1949. Since then, 25 other Westinghouse reheat units have been started. Reheating experience to date is fully satisfactory. In fact, one of the two types of 90 000-kw units recently added to the line of standardized machines employs reheat. Two such machines of this new highest rating standard are being built at South Philadelphia.

Experience has been accumulating with the new top temperature of 1050 degrees F, initiated at the Sewaren Station of the Public Service Company of New Jersey late in 1948. And it has all been good. The Westinghouse machine at Sewaren was opened after 15 months for a look. The creep was less than had been expected. None of the deficiencies found were fundamental and all were readily corrected. Four other machines for this temperature, two of them for a rating of 150 000 kw, have followed at Westinghouse. The experience with 1050 degrees F has given turbine designers confidence to tackle a machine for 1100 degrees F, when it is desired. At present, however, maximum steam conditions have leveled off at 1050 degrees F and about 1800 pounds pressure.

The higher steam temperature has led to an improved and simpler design for the high-pressure turbine element. It is now separated physically into two turbine casings, an inner and outer chamber; and, with separate nozzle chambers, it forms, in effect, a three-casing design. The steam pipes are arc-welded to the outer chamber instead of being bolted. Because the high-pressure turbine element is separated into three chambers, with the pressure differential reduced on each, much thinner walls can be used. This is of great advantage in reducing the stresses due to thermal shocks when starting and stopping or loading a machine. (The local stresses due to heating may be ten times those resulting from steam pressure.) While this stress reduction is important now, it is really done with an eye to the future, when these machines—the pride-and-joy base load units of today—become the peak load machines of tomorrow.

One new tool, used by the turbine designer to squeeze a few more useful Btu's out of the steam in transit between inlet and exhaust, is the use of twisted and warped blades, sometimes called vortex blading. These blade configurations are used to insure a more uniform flow of steam throughout the passage between adjacent blades. With long, straight blades, steam may eddy or flow nonuniformly, with a resulting loss in efficiency.

Among generating units of unusual interest are two not for central-station service. One is of 20 000 kw for Bethlehem Steel Company and comprises a 3600-rpm steam turbine driving a 25-cycle (1500-rpm) generator through a gear—the largest ever built for land service. The other is a 30 000-kw machine for Dow Chemical Company. This is a non-condensing unit with steam extracted at two points. It is the largest double-extraction machine ever built.

The Generator End—Another "largest" turbine generator took physical form last year. The first of several being built on this bigger frame by Westinghouse started on its way last fall to the Gorgas Station, Alabama Power Company. It will deliver 100 000 kw at 0.9 power factor, 3600 rpm. Others of comparable rating are following for Union Electric Company of St. Louis, and Public Service Electric and Gas Company of New Jersey. Engineers take these big machines in their stride, not finding it necessary to institute basic design changes to achieve the larger outputs. That fact in itself is significant. Maximum sizes have not been reached.

The time between final assembly of a big generator and its delivery of kilowatts is being shortened about three weeks by shipping it assembled, sealed in dried air. Generators of 60 000 kw (standard) and less are transported with the rotor in place. Metal caps are placed over the shaft extensions and sealed. Joints and bolt openings that might admit air are covered with plastic. All ports are covered with plates and sealed. Ample quantities of silica gel are placed within the machine to keep the air dry. Behind a single transparent window is placed a silica-gel humidity indicator to give a visual check on dryness. Rotors when shipped separately are covered with an aluminized fabric wrapper and sprayed with a plastic that is nonporous to water vapor.

Also expediting installation is the modern practice of incorporating the current transformers in the generator high-voltage terminals. Not only does it reduce field-assembly time but also saves room in the powerhouse. The space occupied by separate generator-metering equipment may be as large as a single-car garage. A new design of generator-terminal metering is rugged, accessible, and allows room for up to three current transformers encased in plastic and aluminum.

Credit a new blower with enabling turbine generators to carry bigger loads. It is a double-row blower consisting of two rows of propeller-type blades of conventional shape. The rows abut, and the blades of the second row are at a much steeper angle than ordinarily. The result: the air volume is increased about a third; the pressure, by two fifths.

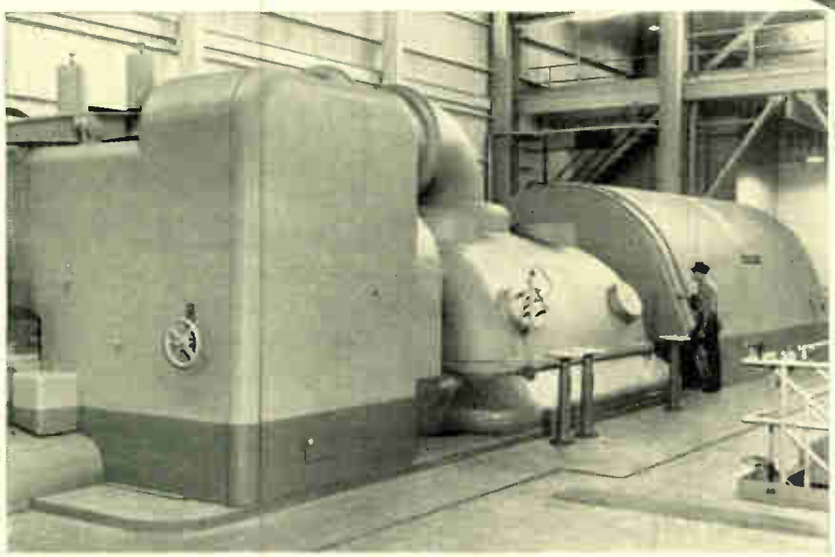
Another biggest in a very different generator field went into service last year. It is a machine for generating high-frequency energy for induction heating. It develops 1500 kva at 3600 cycles and runs at 3600 rpm. The previous largest Westinghouse machine of this class was rated at 1250 kva.

A Once-In-20-Year Insulation Betterment

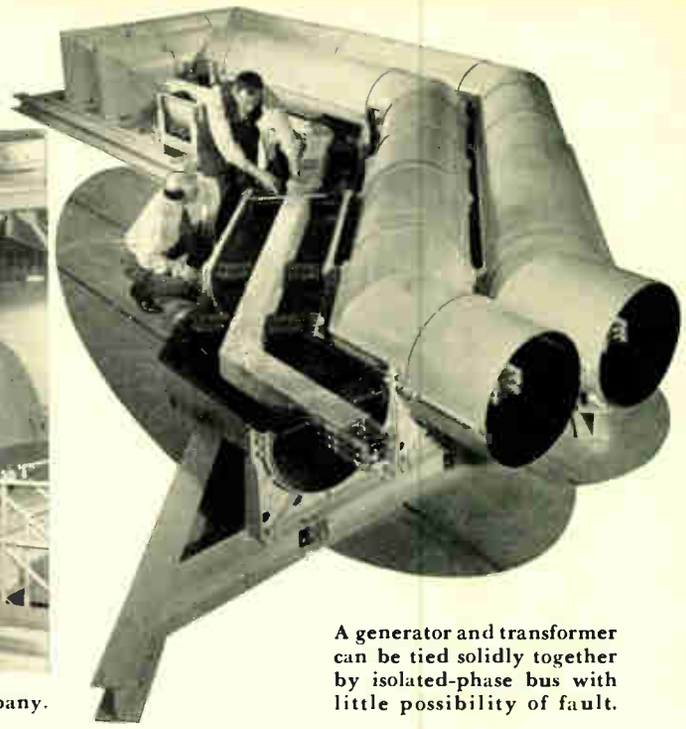
BY COINCIDENCE, major improvements in insulation for high-voltage generators have appeared at almost exactly 20-year intervals. Mica was first used in the early 90's. About 1911 the mica-folium with shellac binder came in. In 1930 the asphalt-impregnated, continuous mica tape was introduced.

In keeping with this chronology, another was due. It arrived on schedule, last summer. It is called Thermalastic insulation, a product of ten years' research and development effort. It has so many spectacular properties that it rightly deserves a place in the insulation hall of fame.

Each of the insulations of history served its era well. But



A 105 000-kw generating unit in the Burger F Plant of the Ohio Edison Company.



A generator and transformer can be tied solidly together by isolated-phase bus with little possibility of fault.

machine sizes have continually grown. Coils always became longer—eventually reaching dimensions that brought into focus the limitations of the existing insulation. The principal deficiency of the asphalt-mica insulation is its one-way plastic flow. When applied to long coils in turbine generators it expands with the copper as temperature increases, but on machine shutdown it does not fully return to its original position. This effect is cumulative over years of machine operation and is known as tape migration.

Thermalastic tape stops that. The impregnant is not asphalt but a synthetic resin, which provides the coil with elasticity in contraction as well as expansion.

It possesses other significant advantages, some in its manner of application, others in final performance. The new method of insulating a generator coil is to apply all the necessary layers of mica tape at one time, without impregnant. It is then heat and vacuum treated—still without impregnant. After this the synthetic resin is applied and set by heat. Thus, impregnation is a single operation, possible because the resin is water thin and can be relied upon to penetrate all layers of tape. Asphalt impregnant, being more viscous, must be applied after each few layers of tape, making a multistep process—and an unpleasant one to apply.

Synthetic resin used in the Thermalastic process requires no volatile solvents. It sets once and for all under heat without loss of any constituent. Hence no voids are created.

The mechanical and electrical properties of Thermalastic insulation are so good as to be almost unbelievable. Insulation power factor is reduced by a half to two thirds. Dielectric strength is at least one fifth better, probably more. Voltage endurance is improved by some large number of times—certainly more than ten. At 100 degrees C it is 30 times stronger in tension. Moisture resistance is vastly superior.

The insulation-development engineer of 1970 has something to shoot at!

A Physical for Generator Insulation

NO ONE questions the wisdom of an occasional physical checkup, even when everything seems normal. This is as true of machines as of men.

Engineers, like doctors, find it more difficult to create test devices that safely search out incipient trouble than to diagnose ills after they occur. This certainly is true of the condition of electrical insulation of large a-c generators. However, recent developments have gone a long way towards placing in the engineers' hands the tools by which the "health" of generator windings can be accurately—and safely—determined at any time in the machine's life. In fact, power companies are now arranging with Westinghouse service engineers for periodic checkups on their generators using these new techniques and tools.

An exhaustive research program, recently completed, has provided some entirely new insulation data, from which stem some of these new testing procedures. Many surveys of generator-insulation test methods have been made but they were on insulations of different kinds and ages, which complicates interpretation of the results. The recent research study has been made under truly controlled conditions with specimens of identical structure and age. Also the tests were made on the insulation components as well as the final assembly. The principles of statistical analysis also have been applied to the problem with important results.

Outstanding among the results is the superiority of d-c potential for testing instead of the commonly used alternating current. Direct current, it turns out, is just as searching of insulation weakness and is not as damaging as alternating current. The longer a high a-c voltage is impressed on insulation the more it is damaged. The effect is cumulative with time, regardless of whether it is continuous or intermittent. One explanation is that with alternating potential the insulation structure is bombarded by fast-moving (and thus high-energy) ions, causing an actual erosion. This explains the lack of recovery of insulation strength after removal of the a-c potential. Long-time tests with direct current are much less damaging than with alternating current.

Based on this knowledge, a portable d-c potential test set has been developed that can be carried to the machine in service. This test, plus several others that have been found effective, comprises an array that will ferret out insulation weaknesses on location without damaging good insulation. Some power companies are arranging to have their generators given such an overall "physical" periodically.

Circular Isolated-Phase Bus

THE PRACTICE of tying a single big generator and transformer together solidly as a unit is increasing. This makes it important that nothing happen to the run of heavy copper connections between them. Also, if this bus can be left without attention for several years, so much the better. This construction of round, metal-enclosed isolated-phase bus achieves just that. It is made completely dust tight by special heavy-cork seals. To take the heavy magnetic stresses the insulators are arranged to carry loads in compression only. The section next to the generator terminals is a ventilated air lock so that no hydrogen can seep into the remaining air-tight sections. Other applications are bus and connection runs and delta connections for large transformer banks.

Monarch Butterflies

THE KINETIC energy of water rushing through a penstock down a mountain side to a powerhouse is tremendous. If this energy gets out of hand, or if a landslide or snowslide breaks the pipe, or something goes wrong with the waterwheel, the effect is "as if all hell broke loose." Hydro-power plants have been damaged and even completely destroyed when the upper end of the penstock was not equipped with valves, or if they failed to operate properly.

Butterfly valves for this service are not new, but last year four extremely large ones were placed in service at the Pacific Gas and Electric Company's Rock Creek and Cresta powerhouses on the Feather River. These are 13 feet in diameter. The static head of one set is 109 feet and the other 145 feet. Pitot tubes located in the penstocks upstream cause relays to close these valves when the normal velocity is exceeded by 20 percent, indicative of an abnormal condition. In such a case, a maximum free discharge flow of 5300 cubic feet per second must be closed off.

A 19-inch diameter shaft supports the valve leaf in two trunnion bearings and is turned by a 5½-foot arm with over one-half million pound-feet of torque. The design problem is similar to that of steering a ship with a rudder engine. A summation of hydrodynamic, hydrostatic, and trunnion and seat frictional torques, changing in both the opening and closing direction, must be computed. Operation, as in turning a ship's rudder, may be by hand, by electric power, or hydraulic. On these valves a 26-inch diameter piston, with a 96-inch stroke, operating with oil at 285 psi, opens or closes the mechanisms in a time that can be adjusted from one to six minutes, depending on the surge pressure in the pipe that is to be protected.

The Gas Turbine

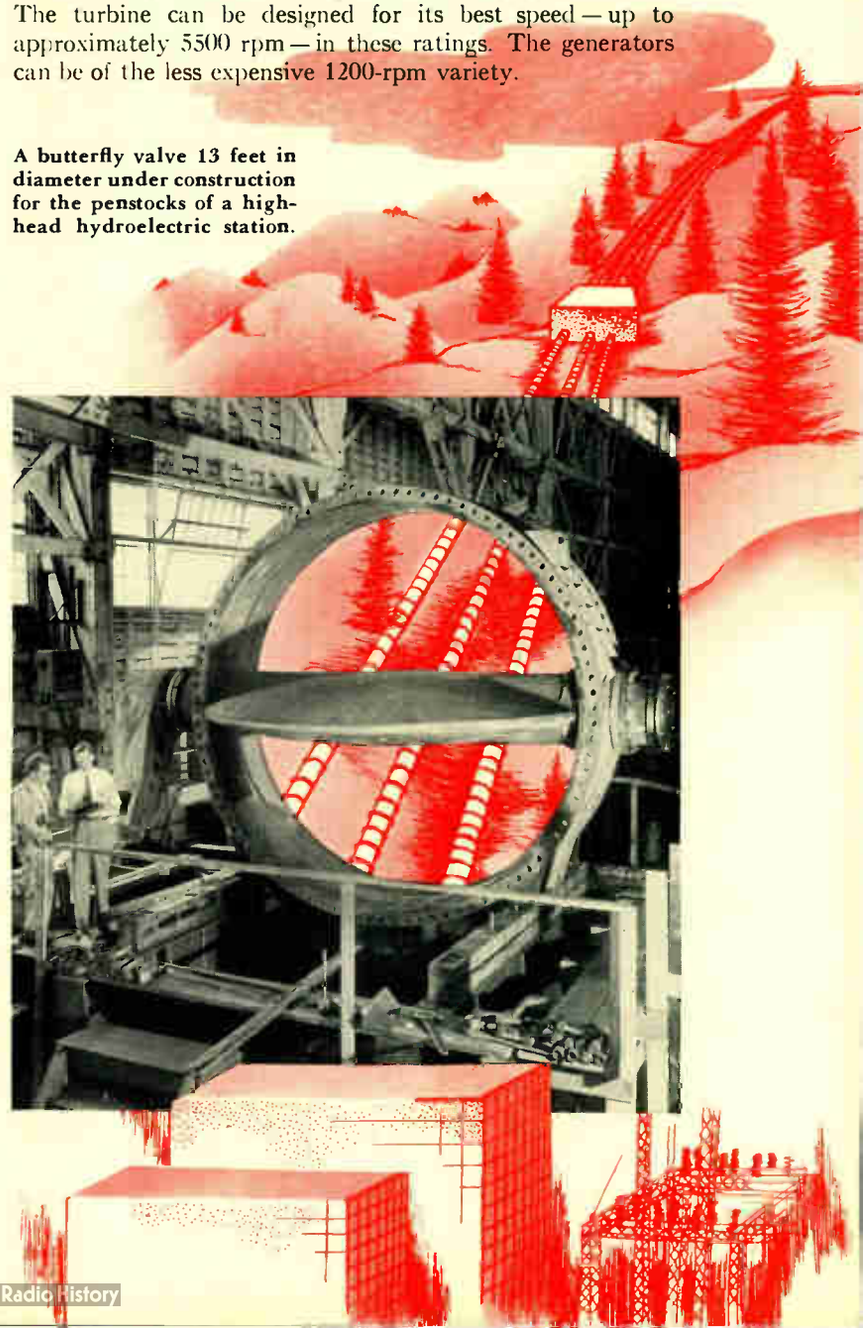
GAS TURBINES have passed from the spectacular stage to that of detail improvement and testing. The 2000-hp industrial gas turbine was placed in experimental gas-line pumping service at Wilmar, Arkansas, in May, 1949. This unit was the first stationary gas turbine to go into service in the United States burning natural gas as fuel. In January, 1950 an endurance run of continuous "on-the-line" operation was started and continued for approximately 1500 hours. Since April, 1950, the unit has not been operated due to the seasonal decrease in load on the gas line. There have been difficulties—as would be expected from any prototype—but none of a fundamental nature, and it is expected that this type service will be a major field of gas-turbine application.

An industrial power-generation unit of 5000-kw rating is the next gas-turbine development, and it is now under way.

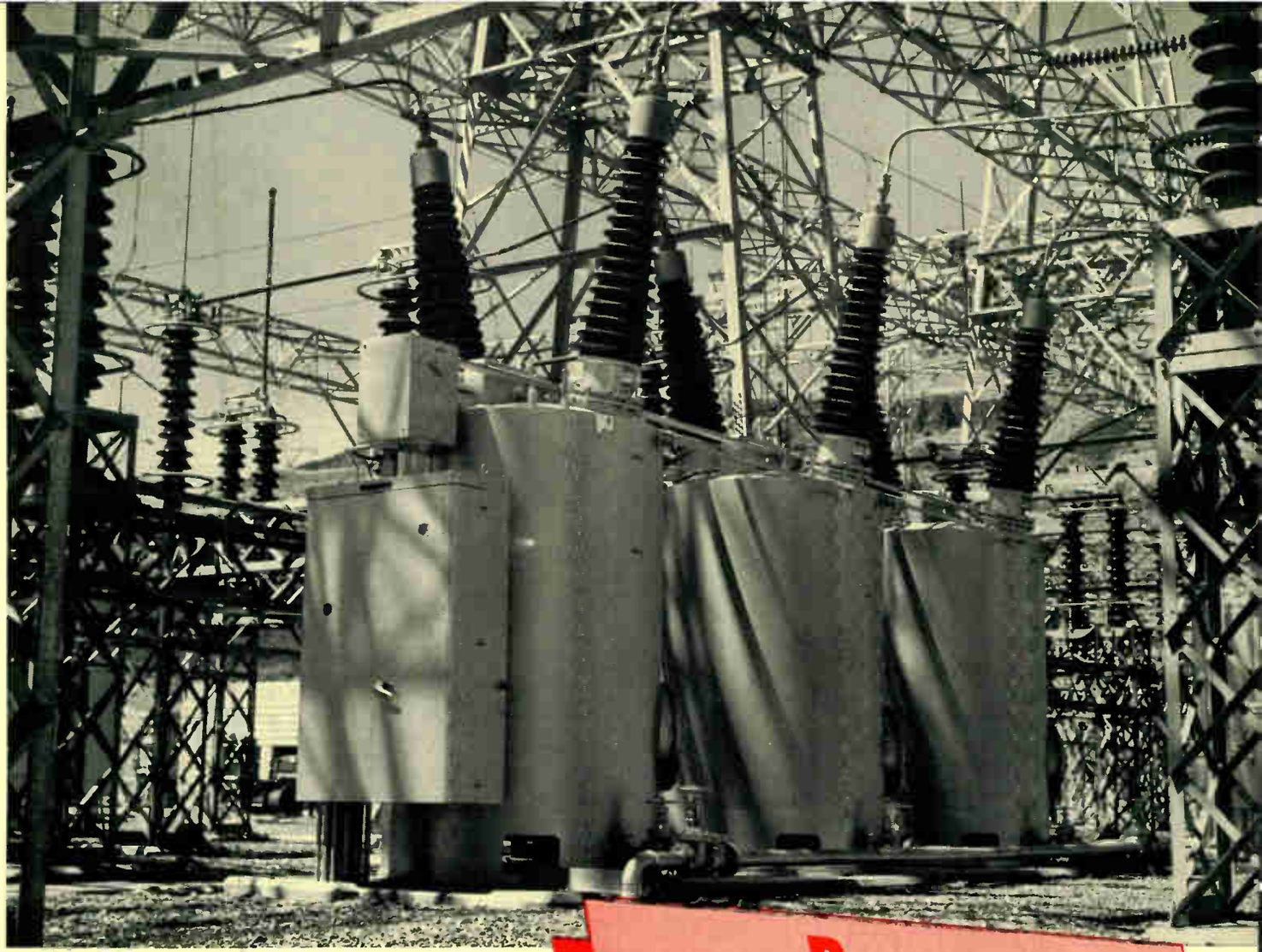
Trends in Small Steam Turbines

SMALL TURBINES in increasing numbers, in the sizes up to 1500 hp, have become completely packaged units. Whether the turbine is for direct drive, with a gear, or combined with an electric generator, it is one physical unit, handled and installed as such. The oil reservoir heretofore has been separate, requiring supplemental piping. Now the bedplate houses the oil reservoir and no external piping is necessary. Lowers foundation costs; reduces installation labor.

The steam turbine is by nature a high-speed machine—of many thousand rpm. The electric generator is best suited to much lower speed. Operation of the two direct connected at even the maximum a-c generator speed of 3600 rpm is a compromise, albeit a good one. With improvements in gears, and with the more common acceptance in industry of machines running at several thousand rpm, the trend is toward geared drives. Whereas geared drives were previously limited to about 500 kw, now this arrangement is extended to 1500 kw. The turbine can be designed for its best speed—up to approximately 5500 rpm—in these ratings. The generators can be of the less expensive 1200-rpm variety.



A butterfly valve 13 feet in diameter under construction for the penstocks of a high-head hydroelectric station.



One of the twelve circuit breakers installed at Grand Coulee Dam that are capable of interrupting 10 000 000 kva at 230 kv. Interruption is by an improved multi-flow De-ion grid.

Power Transmission and Distribution

Power Circuit Breakers

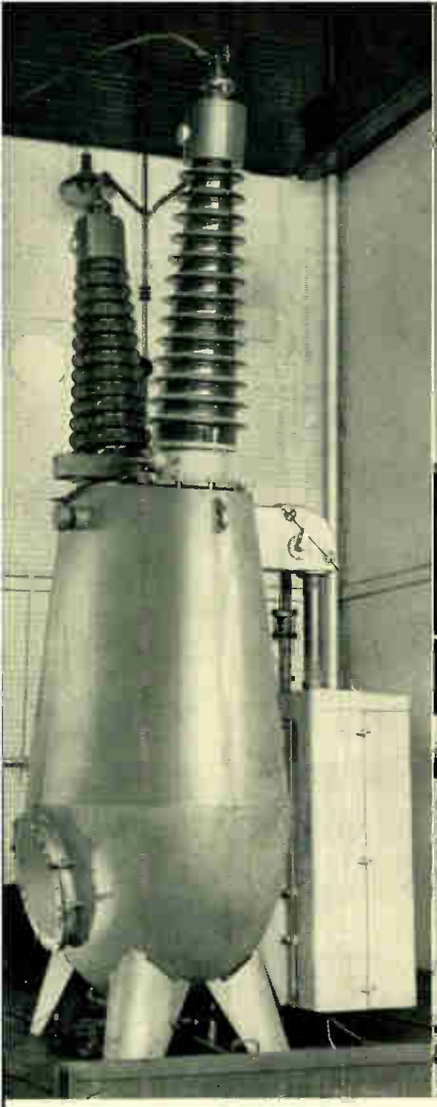
Just six years ago, when the maximum available circuit-breaker interrupting capacity stood at 3½-million kva, two engineers presented a paper stating that the next probable step would be 5 million. Last summer several 230-kv breakers of 10-million-kva rating were installed, and in August tests were made on one with short circuits of 10⅔-million kva. The 5-million step was quickly passed. Such is progress and the hazard of prophecy.

Because of the enormous power concentration at Grand Coulee Dam, twelve of these 10-million kva dead-tank oil breakers have been installed. Also four are being built for Hoover Dam and eight for the Bureau of Reclamation's Central Valley project. These are all 3-cycle, 230-kv breakers.

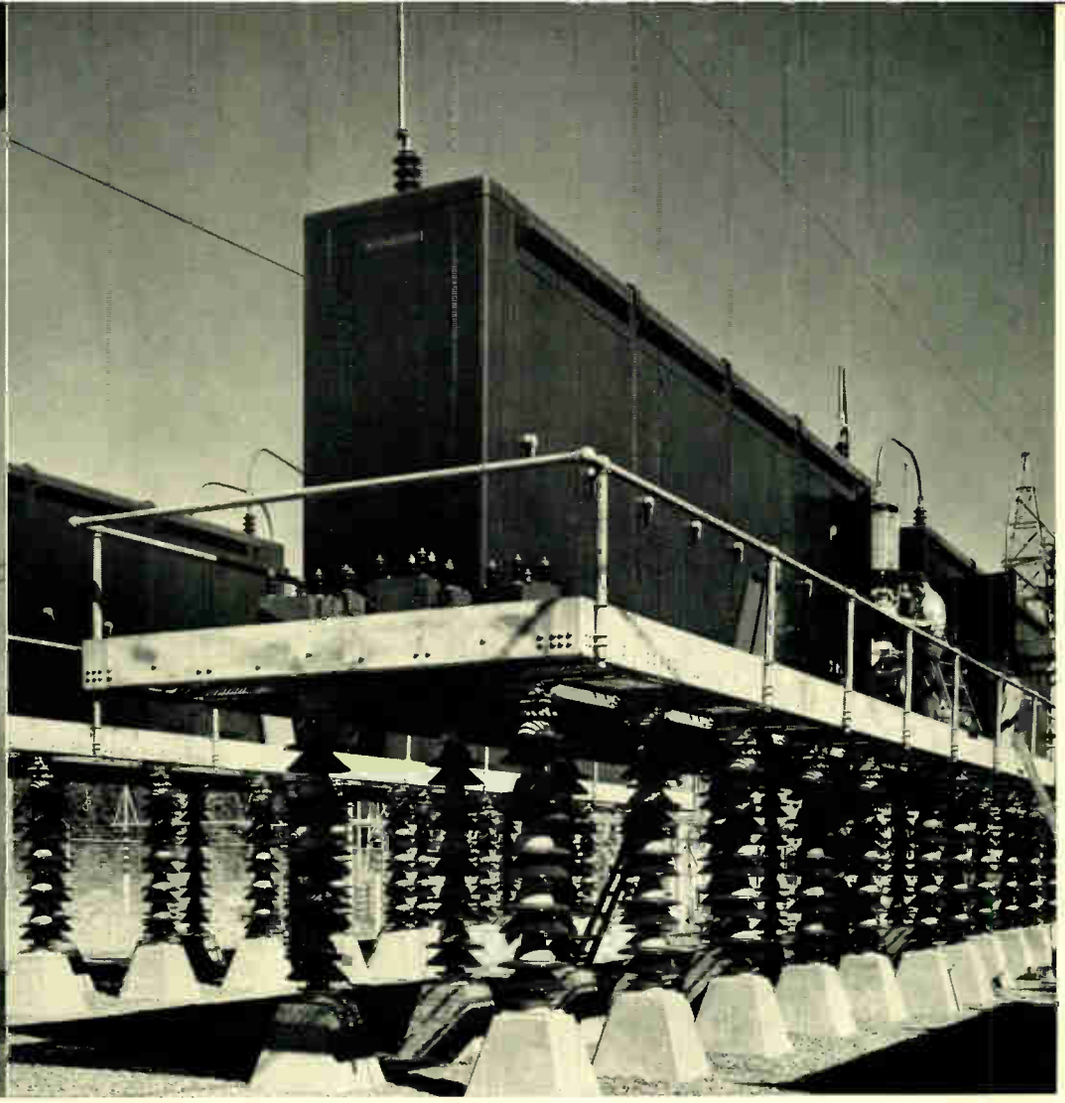
The Coulee installation is additionally interesting because six of the dozen are rebuilt 3½-million kva units. Ten-million kva capacity in the tank originally used for one third as much interrupting ability! The gain has come in an improved interrupter, a multi-flow De-ion grid, with an exterior pneumatic operating mechanism. The Bonneville Power Administration has also rebuilt four of their 2½-million breakers for 10-million kva.

Even before engineers catch their breath from that assignment, a more difficult one appears. It is to provide similar high interrupting capacity at lower voltage. The TVA-power engineers have placed orders for 7½- and 10-million kva breakers on their 161-kv system. There is some talk of similar capacities at even the next lower transmission voltage. This means more current for the same short-circuit ability. It is the magnitude of this current to be carried and interrupted that gives breaker engineers their stiffest problems.

However, designers anticipate no serious difficulty in meeting these more extreme ratings with the present type of interrupter, although a change in the type of contact will possibly be necessary to handle the larger currents. In fact, short-circuit capacity of breakers does not appear to be a bottleneck to growth in high-voltage system power concentration in the foreseeable future.



A circuit-breaker tank that fits the interrupter more closely requires much less oil. Such a 7½-million kva, 230-kv breaker needs only 3900 gallons of oil, compared to 6900 gallons formerly.



A 15 000-kva series capacitor on the 230-kv Bonneville system increases the line load capacity by a fourth. During system faults the capacitor is not removed; only the excess current is bypassed.

Compressed-Air Circuit Breakers

FOR CROWDED metropolitan areas, engineers prefer devices without oil. This has spurred development of compressed-air breakers for higher voltages. Several such have been built for 69 kv. Except for a few experimental units, these are the first in this country for voltages above 34.5 kv. These units carry 2000 amperes, have 3 500 000-kva interrupting capacity. Although these are the indoor-type units, they are fitted into outdoor cubicles.

Compressed-air breakers are occupying less space. The new 2000- and 4000-ampere, 15-kv units run from 10 to 30 percent less in space requirements. That spells less powerhouse volume, i.e., less investment. Without any sacrifice in performance or insulation level the 4000-ampere unit, for example, fits into a cubicle 68 inches wide instead of 81 inches.

Air Circuit Breakers

TWO OR MORE low-voltage air circuit breakers can be applied to operate as a team, i.e., arranged for selective tripping, without such auxiliaries as overcurrent relays and current transformers. Each breaker has built into it selective overcurrent series trips containing a timing device responsive to current. It can provide tripping delay for any current up to the interrupting rating of the breaker.

The type-DB air breakers, which are built in interrupting ratings of 15 000 to 50 000 amperes, for a-c voltages up to 600, and d-c up to 250, have also been improved mechanically, although the interrupter principle remains unchanged. Capitalizing on many years' experience, these are built of unit assemblies and sub-assemblies suitable for line-type manufacture. Also the unit assemblies greatly facilitate the removal of an element in the field for servicing.

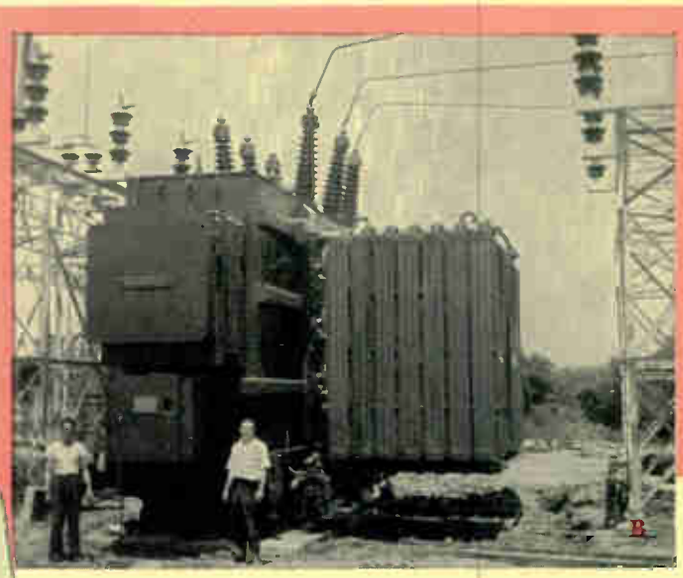
The timing device in the overcurrent trip used on the DB-15 and DB-25 is the sealed-chamber type, which uses a silicone fluid with a non-adjustable orifice as the timing means. The values of current pickup are adjustable, but the timing is set and sealed in the factory.

The overcurrent trip for the DB-50 air breaker is of the air-delay type in which all time and current values are adjustable. The time adjustments are obtained by admitting air at a controllable rate behind a flexible diaphragm.

The type-DH air circuit breakers in the 5- to 15-kv classes no longer must have a supply of electric power at hand for their operation. In some small isolated substations it may be inconvenient and expensive to provide battery power or a transformer for the small and infrequently used energy needed for breaker closing. For such places a stored-energy spring-closing device has been developed. The energy thus stored is sufficient for a single closure of the breaker against a current of 60 000 amperes, as proved by short-circuit tests in the high-power laboratory.

A—A large power transformer with its battery of cooling fans and radiators begins to take shape on the assembly floor. *B*—An 80 000-kva, 161-kv power transformer recently installed by Kansas City Power and Light Co.

C—Under this mass of ice in the high-power laboratory are two disconnecting switches, one open, one closed. An instant later they both operated perfectly. The water was frozen in special fashion to create the type of ice most difficult to break. *D*—The earliest outdoor metal-clad switchgear employed modified indoor construction. Now it is designed specifically for outdoor service, with more rigid construction, and better appearance.



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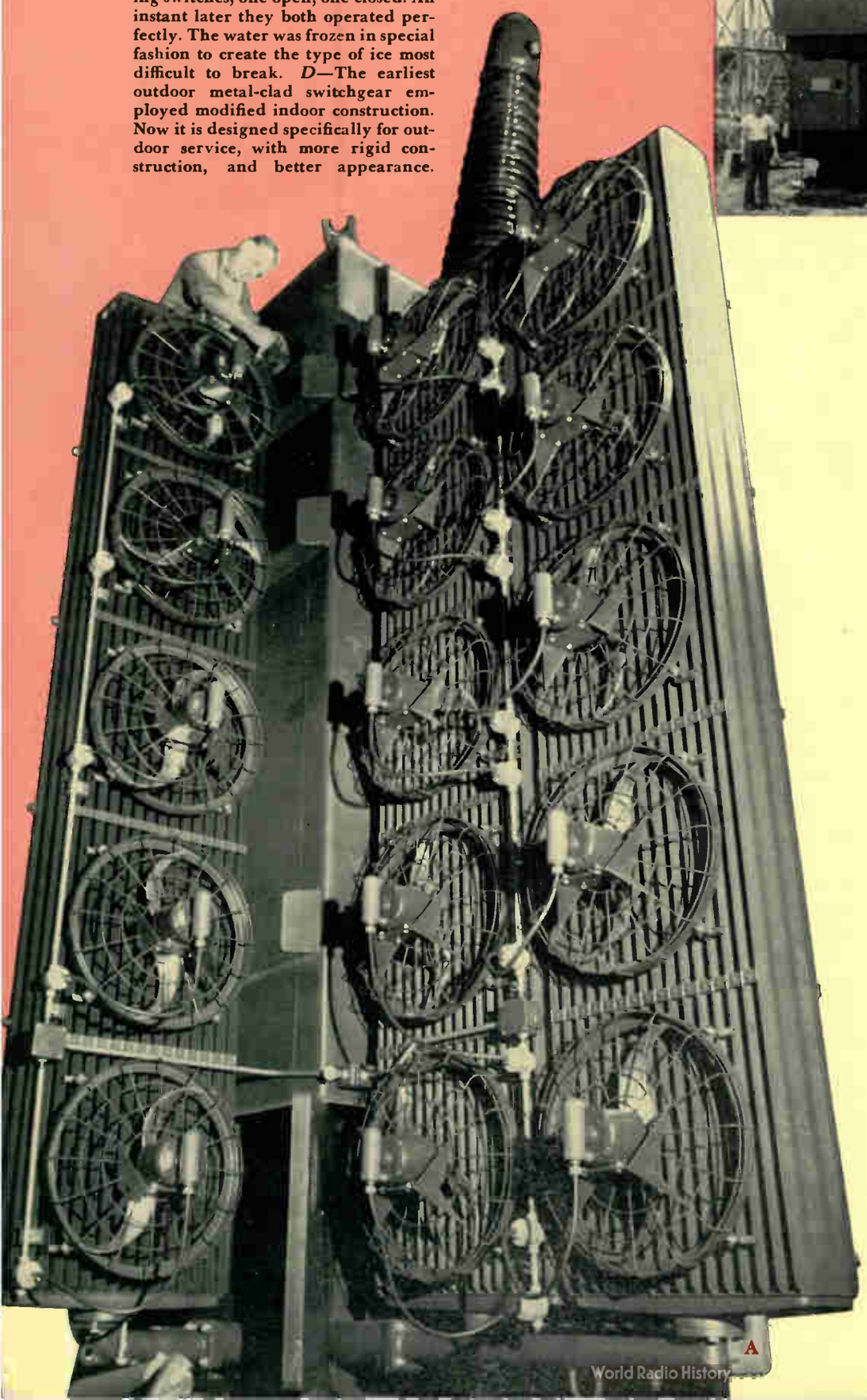

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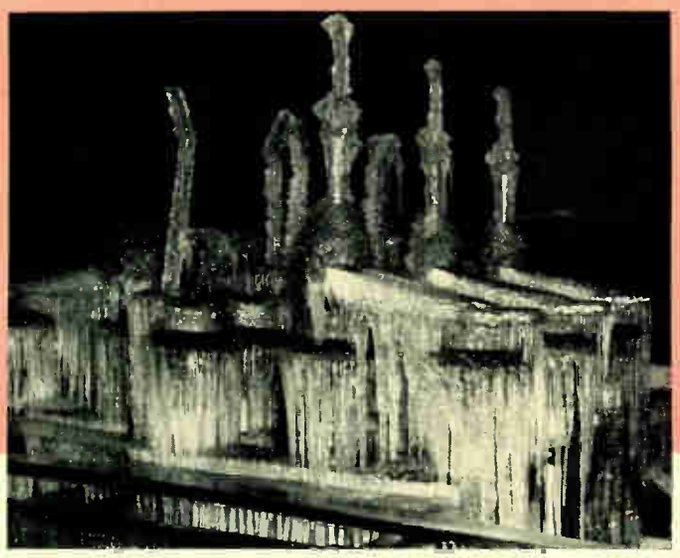
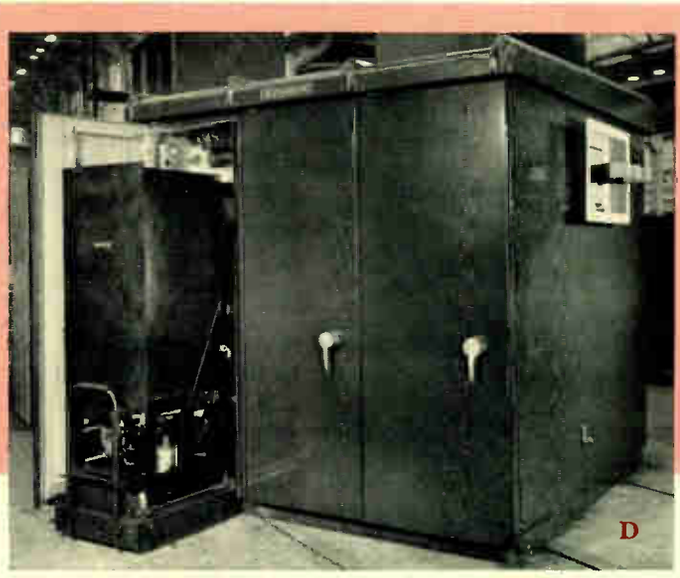
The High-Power Laboratory Celebrates a Quarter Century

TWENTY-FIVE years ago last month an engineer closed a switch and a heavy slug of current surged through a type 0-11 breaker. This was test number one. This was the initial operation of the new high-power laboratory, which, since its enlargement in 1939, is the largest in the world. Thus began a notable quarter century of high-power laboratory testing. A quarter of a million short-circuit tests have been made. (However, because of the fractional-second brevity of each test, this represents but six hours of total short-circuit operation on the generators.)

The more important statistic would be the money the laboratory has saved the industry. This figure is enormous—and incalculable. The ability to make short-circuit tests under controlled conditions, at will, as the handmaiden to interrupter development has been worth millions. The time saved by eliminating many months of field testing has contributed to a much faster rate of progress in circuit-interruption development. It is, in short, because of the high-power laboratory that the accompanying stories of switchgear progress can be written.

A single example of the usefulness of the high-power laboratory is the work done last year to test a low-voltage switchgear to be used on a system of abnormally high short-circuit current capabilities. This 600-volt metal-enclosed switchgear was required to withstand short circuits of 200 000 amperes. The first of several such gear was provided with the calculated extra heavy Micarta bracings and tested in the laboratory. The test proved both the adequacy of the specially designed supports, and demonstrated—rather spectacularly—that





all of them are needed. The user can apply these switchgear elements with complete confidence.

Progress in Power Transformers

ALTHOUGH POWER transformers have each year been setting new records for size, the present highest rating remains the 145 000-kva, 135-kv, 3-phase unit installed in Detroit in 1949. That does not mean, however, that transformer engineers have run into a capacity ceiling. Last year they were asked to study the possibility of a 200 000-kva, 230-kv, 3-phase transformer. They agreed it can be built when and if such a giant is needed.

There were many very large transformers of unusual engineering interest designed or built in 1950. Each presented a challenge to the designer because invariably these big fellows are custom built and generally have some unusual and often difficult situation to meet.

One large unit for a middle-west utility—of 80 000 kva with tap-changing-under-load equipment—was required to have four windings in order to tie together several systems at different voltages, thus providing greater flexibility in controlling flow of power.

Power transformers of 10 000 to 20 000 kva on highway trucks for quick mobility about power systems are not uncommon; but now two truly king-size mobile units are being constructed. Each has a rating of 83 333 kva and will be installed on a special railroad car for use as a spare in several 250 000-kva banks at widely separated parts of the Bonneville system. Lightning arresters and coolers only must be removed when a unit is in transit, and these are carried on the same car. This large capacity in a mobile unit is made possible by the form-fit tank and shell-form construction that permits effective use of directed oil flow and allows the transformer to be operated horizontally instead of vertically.

Numerous detail improvements have appeared in power-transformer construction. The air-cooling system is improved and made quieter. Vibration has been minimized by a new flexible cable on the fan motors instead of rigid conduit, and in some cases the use of slower speed motors. Neoprene cables with weatherproof connections to the motors make for easier removal for servicing. A thermal protection system has been devised for the three-phase fan motors where they can be used. This makes unnecessary the use of fuses and their servicing when ice, for example, causes overload.

A power transformer may have several thousand feet of wiring not involved in the unit's main business of voltage transformation. This is in control wiring for such things as the tap-changer equipment, protective devices, blower motors, etc. The rubber-covered wire customarily used has been replaced by a wire insulated with a synthetic covering. Unlike asphalt-covered braid it does not absorb either water or oil; the result is a wiring system that retains its electrical strength under adverse conditions. The insulation is tougher and hence is less likely to be damaged when drawn through conduit; it is thinner and hence occupies smaller space, i.e., requires fewer or smaller conduits; yet it has twice the dielectric strength of rubber-covered wire.

A power transformer represents a sizable investment and in addition is vital to service continuity. Devices that protect it against every hazard are, therefore, valuable insurance. A new one minimizes damage when an internal short circuit generates a huge volume of gas. Transformers have relief diaphragms that act when internal pressures build up to an unsafe amount; but a new device does even better. It recognizes any uncommon rate of change of pressure and gives an alarm or removes the transformer from service long before the relief valve can act. The relay detects a pressure rise of slightly over an ounce per square inch per second.

A Variety of Relay Improvements

RELAYS ARE the "brains" of electric transmission systems. They are precision devices, often with watch-like mechanisms, comprised of gear trains, coils, magnetic circuits, tiny motors, and similar elements. The things that can be done with them in proper combination seem infinite. Likewise the improvements and new things engineers find to do with them appear endless—as illustrated by a few recent examples.

Double-Loop, High-Speed Relay Element—The inherent advantages of the inductor-loop construction used in the high-speed directional element have been further utilized by the design of a double-loop element. The double-loop construction eliminates the double-frequency torque pulsations of the single loop, resulting in a smooth, steady torque that greatly increases the sensitivity and reduces the mechanical wear.

The element is constructed so that it is easily disassembled for maintenance.

Electronic Telemetering System—Telemetering received a lift last year by the introduction of an all-electronic circuit for the high-rate impulse (frequency) telemetering system. A d-c voltage proportional to the quantity to be transmitted is fed into the electronic circuit and converted into impulses. The new system is fast, being able to indicate a change in metered quantities in less than one second. The system can easily totalize any number of quantities and can be used over any kind of communication channel.

Extremely Inverse Overcurrent Relay—One of the oldest of relays, the type CO overcurrent relay, has appeared with a modified operating characteristic. It is called the type CO-10 and has a time-vs.-current characteristic that is extremely inverse. This means that a relatively long operating time is obtained for light overloads and relatively short operating time for heavy overloads. This characteristic is useful for coordination of settings between fuses and relays. It is also useful for distribution circuits where there is considerable load diversity, by allowing reclosing, without unnecessary load segregation, after an extended outage. Fast operating times for fault conditions are retained.

Voltage-Controlled Overcurrent Relay—More sensitive back-up protection for a-c generators is provided with a voltage-controlled overcurrent relay. Voltage control permits setting below full-load current, hence the relay will operate only for short circuits that cause the voltage to drop below a predetermined value. This relay (COV) is a combination of an instantaneous-undervoltage element and a time-delay-overcurrent element.

Variable-Percentage Differential Relay—The variable percentage characteristic for differential relays has been proved by many applications of the type CA-6 relay to bus protection, and of the type HA high-speed differential relay for generator protection. This principle has now been extended to transformer differential protection in the new type CA-5 relay. The relay is relatively insensitive to magnetizing inrush, yet provides a greater sensitivity to light internal faults than the type CA. At the same time, through the variable percentage characteristic, it has a wide margin of safety against incorrect tripping for external faults.

Reflectors like this permit microwave-communication stations to be located even with an obstacle intervening.

Distribution Fault Finding and Isolation

A PAIR of new devices acts as a team to improve even further the already high order of reliability of long distribution circuits—and to reduce the cost of servicing when outages do occur. One is a recloser, the other a sectionalizing switch. The recloser is a three-pole version of a single-pole recloser developed about two years ago. It is mounted in a single rectangular tank for pole-top or substation service. When a fault occurs it opens and recloses, rapidly restoring service. On a permanent fault it attempts three times to restore service before locking open. The three poles operate independently but before any one proceeds to final lockout it opens the other two poles.

The sectionalizer is an oil switch located some distance away from a recloser. It has load-current interrupting capacity but is not intended to open short circuits. Its job is to open and isolate its section of the line only while the recloser has the circuit de-energized.

As with any team the two devices must have a means of communication if they are to work cooperatively. They do it this way. A fault occurs on the line beyond the sectionalizer. The recloser opens and closes three times; the sectionalizer meanwhile counts the number of circuit openings. The third opening signifies to it that the fault is within its line section and is permanent. Hence the sectionalizer opens while the recloser has the line de-energized. The recloser continues its cycle, making the third closing and, because the sectionalizer has isolated the troubled line section, can now remain closed to continue service to all other line sections. Because the sectionalizer is less expensive than a recloser, the combination provides economy on distribution circuits over using a recloser at each sectionalizing point.

No Ceiling to Improvement—Even in Distribution Transformers

THE IMPRESSIVE list of recent improvements in the distribution-transformer field clearly demonstrates that no device, no matter how well developed or how basically simple, ever becomes perfect and has no prospect of significant betterment. Last year this oldest of a-c power devices—it was introduced in this country by Westinghouse two thirds of a century ago—appeared with (a) a greatly improved tank form both in looks and in usability, with connections easier to make; (b) a superior surge-protection system; (c) a new finish with at least double the life even in sea and other corrosive atmospheres; (d) an insulating oil with life lengthened by several times; and (e) numerous detail improvements.

An improvement in De-ion arresters for distribution transformers has led to a major improvement in the physical form of the transformer itself. Until recently CSP distribution transformers for 5000-volt service and less were made in two forms. One (for 37½ to 100 kva) was the cylindrical tank with circular cover, and bushings entering the tank through weld-

ed-on pockets near the top. The other (for 25 kva and less) was the cylindrical tank capped with a large overhanging upper section and with leads entering from beneath the overhang. In both, the arresters were mounted inside the tank.

The development of an external arrester, which would eliminate the need for a series resistor, has proved successful, and the first application was to the cover-mounted bushing transformer employing a series gap at the line electrode. A further development of this external arrester has made possible the new CSP distribution transformer (type RW) with high-voltage bushings mounted on the side wall at the top of the transformer tank.

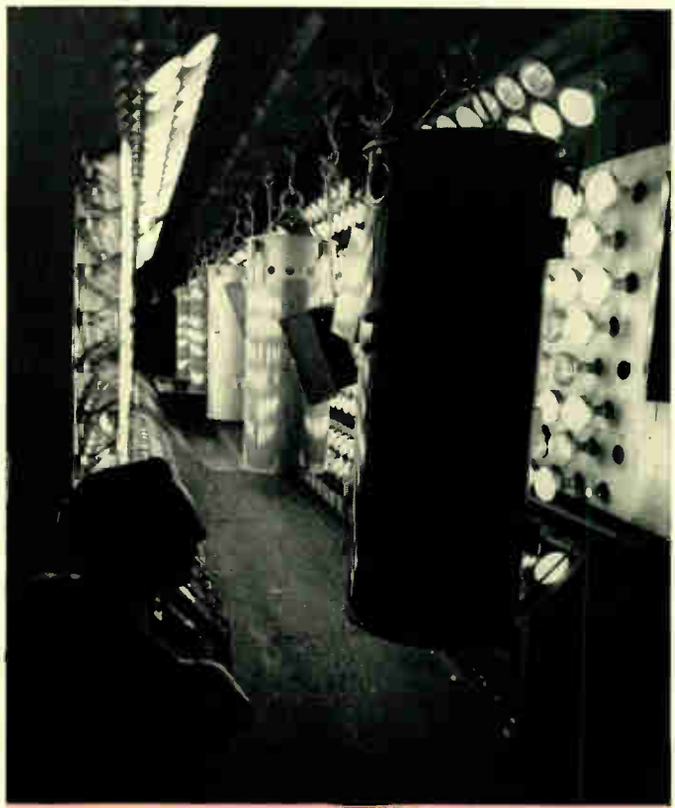
This transformer has several important service features. It employs the so-called disconnect bushing construction, by which connection to the high-voltage line is made simply by inserting the primary conductor from either side of the bushing and turning an insulated knob. No tools are required. The gripping strength of this connection far exceeds previous ones. In plan view the transformer is smaller in the area adjacent to the crossarm than either of the types it replaces, giving better crossarm clearance and more working space for the lineman. The high-voltage bushing has been located a sufficient distance from the hanger lugs to allow the breaker handle to be placed between the lug and the bushing. This makes the breaker handle easily accessible to the lineman, and eliminates the need for reaching around the bushing and arrester to operate the handle.

The completely round tank with round cover provides more effective gasketing and sealing of the transformer and simplifies removal and installation of covers on transformers. A series gap, the upper electrode of which is a component part of the high-voltage bushing assembly, isolates the arrester from the line both electrically and mechanically. Protective porcelain parts cover all live high-voltage terminals, which is particularly important where birds and squirrels are a problem. All porcelains are made larger where they pass through the tank and hence are stronger mechanically than those employed on previous, pocket-mounted units.

This same round-tank construction with external, wall-mounted bushings is also available in the conventional (non-CSP) type of distribution transformer.

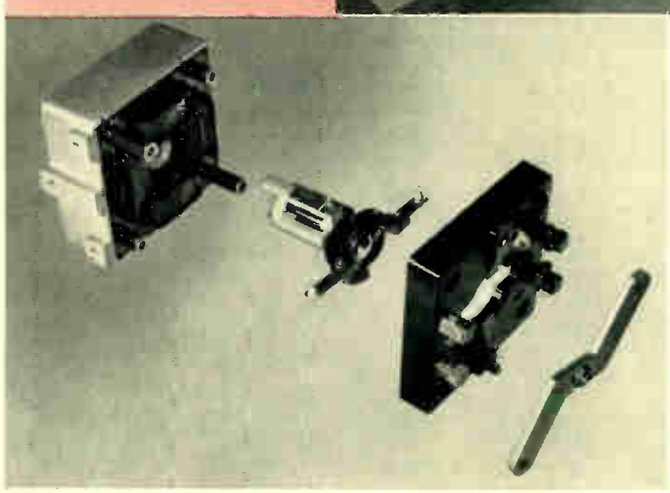
The CSP distribution transformer lives up to its name. If it is overloaded it first shows a warning light, but if this goes unheeded to the point of endangering the insulation, the breaker removes the load from the transformer. However, there are emergency situations when it is better to allow the transformer "to take it"—at a sacrifice in life—than to dump the load. Perhaps a once-a-year peak, like a Christmas-eve load, could be carried in this fashion. To permit doing this, CSP distribution transformers are now equipped with a control on the outside of the tank by which the bimetal is set manually to operate at a higher temperature until the emergency passes (after which it must be manually reset).

The three-phase transformer has taken a two-out-of-three position in the power field. The idea is spreading. Two years ago, the CSP distribution transformer appeared in the three-phase variety. It is available in ratings from 9 through 150 kva for all standard voltages through 15 kv. It makes available all of the CSP advantages for three-phase operation, including the emergency control feature. At the same time, the transformer (CSPB) developed for banking of secondary circuits, and which has met with such popularity for single-phase operation, was produced in three-phase form. These recent developments now extend the advantages and economies of CSP operation to the entire field of distribution.



A new three-layer paint system at least doubles the life of finish on distribution transformers in salt and other corrosive atmospheres. The new finish is baked on as shown above. After equal periods in the standard salt-spray cabinets, tanks with the new and old finish appear as shown.

Exploded view of the new double-loop high-speed relay element. ↓



Longer Life Transformer Oil

INHIBITIONS in humans are in disfavor. But, in transformer oil inhibitors are a fine thing. In fact they are being deliberately added to lengthen the life of the oil.

The trouble maker, mostly, is oxygen, which likes to combine with some of the components of insulating oil to form the always objectionable sludge. Unrefined or moderately refined oil contains some natural oxidation inhibitors. But there has been a trend toward higher degrees of oil refinement in order to remove objectionable impurities. Unfortunately, deleting some undesirable compounds also removes some desirable natural oxygen inhibitors.

The problem of added inhibitors for transformer oils—particularly those in which breathing of oxygen cannot be entirely prevented, as in distribution units—has been a research laboratory study for several years. Before an inhibitor could be safely chosen many questions had to be answered, such as: Does the inhibitor have any catalytic or other effect on any of the scores of different materials in the transformer? What effect on the life of oil? What effect on dielectric strength of various insulations? What value in transformers from which oxygen is excluded, like Sealedaire or Inertaire transformers? What should be the initial degree of oil refinement? Altogether it is a complicated matter.

Last fall announcement was made of an inhibitor for oil that research and transformer engineers have found well proved by test to answer satisfactorily all these questions and many more. Accordingly all Westinghouse distribution transformers are being filled with the oxygen-inhibited oil, with a consequent lengthening of the life of the oil by a factor of three, perhaps more.

The idea of oxygen inhibitors is similar to the approach by agriculturists whereby a pest is removed by importing his natural enemy. The worst offense of oxygen in oil is that a molecule of it latches onto an oil hydrocarbon molecule and makes a peroxide of it. The inhibitor, thoughtfully applied by the engineer, stands by to grab the peroxide as soon as it is formed. It doesn't take much inhibitor—for the oil of a five-kva distribution transformer a heaping tablespoonful does the trick. Power transformers, while not needing it so much, are being dosed with inhibitor, too, for good measure.

Step Regulators Take to the Air

STATION-TYPE transformers and regulators employed to regulate voltage have in general been devices in heavy tanks requiring installation on the ground. These devices have recently been supplemented by designs that bear very little resemblance to the old.

The new devices use cylindrical pressed-steel tanks common to distribution transformers. This change, plus the adoption of wound cores of Hipersil grain-oriented steel, has reduced the weight to the point that they are no longer earth-bound. Even the largest can be pole mounted. Weight reduction is one of the outstanding features of the new step regulator. The previous Westinghouse 50-ampere model weighed approximately an even ton; the new one 1240 pounds.

The new regulator (URL-8) provides a range of voltage control of 10 percent in eight 1¼-percent steps. The small steps give smoother adjustment of voltage.

Other important operating improvements have been made. The load-tap-changer position of a unit in service can be read from the ground—saving many a trip up a pole. The ten-percent range of regulation can be shifted with respect to the nominal line voltage (to accommodate basic changes in circuit load conditions) by operating a switch by hand through a cover hole without tools—and without even having to look inside. With this feature a load-current increase is made available when this switch is adjusted to obtain a downward voltage regulation.

All control elements, instead of being mounted fixed as separate elements on a panel, are grouped within a standard, plug-in (Flexitest) relay housing developed a few years ago for switchboard use. Thus the entire control element can be removed without tools by a lineman and replaced instantly by another. The replaced unit can then be taken to the service shop for maintenance under shop conditions and by men skilled in instrument and relay work. Servicing under the handicap of pole-top conditions is avoided. It can be done more readily in the service shop.

The tap-change switch is maintained in a chamber separate from the transformer, so that all carbon formed by switch operation is prevented from collecting on the transformer windings.

To Meet the Demand for More Demand

IN SOME households—such as those that use electricity for heating and air conditioning—the current drawn far exceeds the capacity of the common-garden-variety 50-ampere meter installation. The meter can take it if the connecting conductor size is ample and in keeping with underwriters' requirements. The problem is primarily one of thermal, not electrical, conductivity.

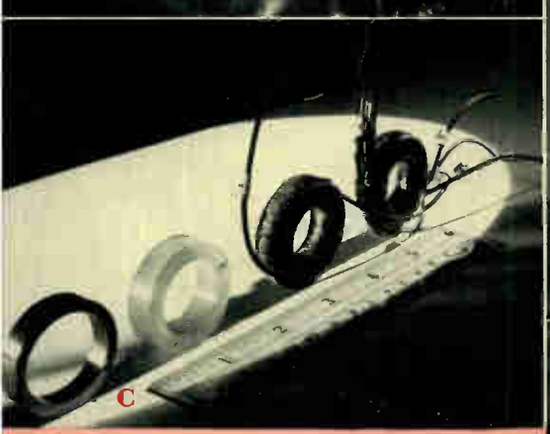
For such situations, a new heavy-current socket has been developed (type STU). It is suitable for loads up to 200 amperes without current transformers. Terminals are made heavy, with emphasis on thermal conductivity, so heat is drained rapidly from both the meter and the socket itself. The socket can take cables up to 4/0 and is provided, if desired, with a switch for automatically closing the circuit to the load when the meter is withdrawn.

For still heavier loads, another socket, slightly larger, can be used for loads up to 400 amperes and cable sizes up to 500 000 circular mils (type STS known as the Transocket). Built into it are new-type instrument transformers (MR) designed to give accuracy in the 0.3-percent class for the metering burdens involved. To facilitate installation, the socket can be connected by the contractor, and the transformer and meter-socket sub-assembly can be readily connected to pre-positioned adapters by the power company later.

Demand metering is increasing in popularity. For this, a single-phase combination watthour and demand meter, using the thermal principle and built in the popular detachable socket, was developed about ten years ago. Now it appears in the polyphase form, thus completing the lines of combination thermal meters. This type of meter has fewer rotating parts. In the new demand meter, accessibility of parts for servicing has been greatly improved.

Some power companies prefer to measure polyphase kva demand (instead of kw). Until recently, the meter for doing this had no voltage element and was, in fact, an ampere-demand meter. Constant voltage was assumed. Recently, a true polyphase, kva, thermal demand meter has been produced. It employs a current-responsive element, the indications of which are modified by a voltage-responsive element acting through a linkage to give true kva indication.

Power Utilization



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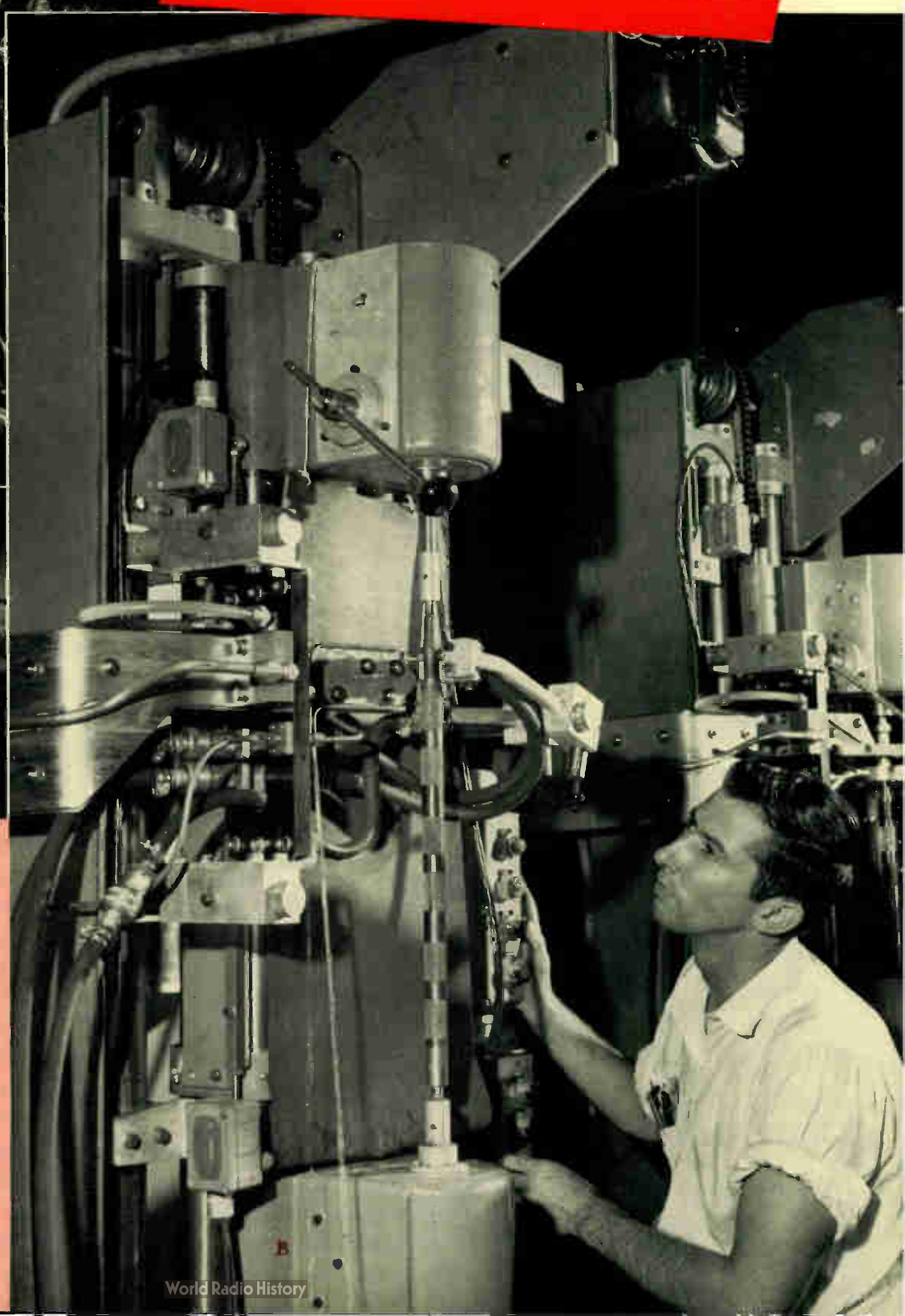

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A—Fractional-hp motors, of NEMA 42-frame variety, move down the production line. These are the new motors with die-cast brackets. *B*—Spindles for textile machines are inductively and selectively hardened automatically in this radio-frequency hardening machine. One station is in operation while the other is being unloaded and loaded. *C*—Four steps in the production of one of the most rapidly developing new devices—the magnetic amplifier. From left to right we have: the core, wound of Hipersil, the core encased in plastic, and two steps in the winding of the coil.

More Lifeline

THE PRINCIPLES of Lifeline-motor construction applied since the war to more than a half million general-purpose, squirrel-cage motors are extending, ripple-like, to many other motor types. Starting at 15 hp, the sizes have steadily crept upward. Now Lifeline motors of 700 hp are in service.

A recent new one is the vertical, hollow-shaft Lifeline motor for pumping water. Suggestive of the great depths water must be pumped with lowering water tables is a motor that must carry a thrust load of 20 000 pounds. This rather extreme thrust for an induction motor is carried by a special spherical roller bearing.

Driving a textile loom is one of the severest jobs for a motor. The torque demands vary rapidly. Severe vibration and shock occur with each passage of the shuttle. A motor specially built for the purpose has been required. A new loom-service motor incorporating many of the Lifeline features is now in production. Except for end brackets, it is of fabricated steel. It uses prelubricated, permanently sealed ball bearings. It has a rotor similar to that of the Lifeline. It has the same pleasing contours. Like all loom motors it is completely enclosed to exclude lint.

Another special type of a-c Lifeline motor is the one for the food industry. This motor has special construction to provide no place for dirt to hide and to take hosing operations common in food-processing plants.

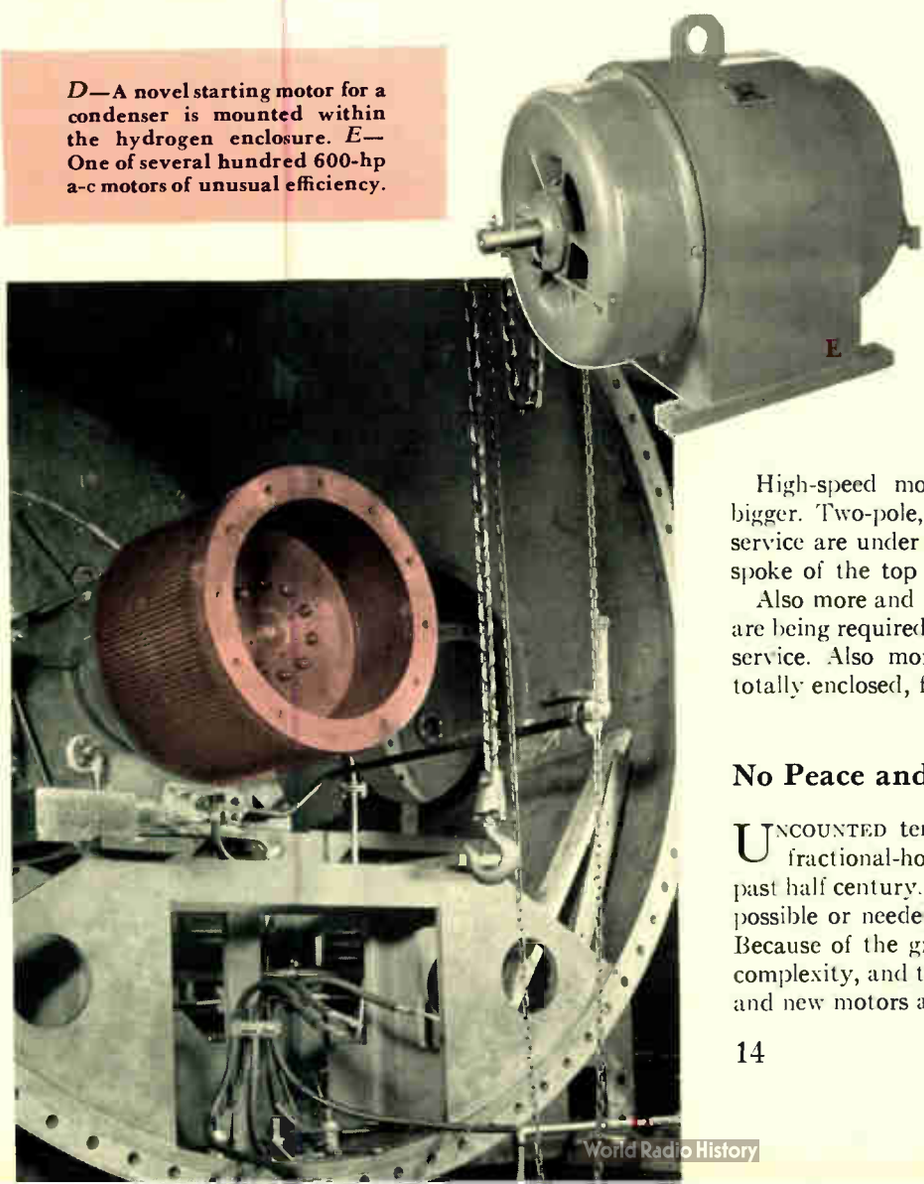
The family of d-c Lifeline motors is now also well established. These motors of from 1 to 30 hp are all steel and use permanently sealed ball bearings. The brush-rocker rings are of glass melamine, which does not char under an arc. The armature coils are wedged in place; no bands. Because of the absence of cast members these motors without further ado are acceptable for naval service.

Big Motors for Special Problems

TO IMPROVE by four percent the efficiency of a device that normally runs better than 90 percent is a real feat. This was accomplished last year with a group of special induction motors of 600- and 700-hp ratings. Also most unusual was the extremely large number of motors required—about 500—for this project, which made possible several engineering features that gave exceptional economy of watts and dollars.

Another interesting large squirrel-cage motor runs within the housing of a synchronous condenser. It is desirable to have a condenser-starting motor within the enclosure to avoid shaft seals through the hydrogen housing. Wound-rotor motors possess the necessary high starting torque to accelerate the high-inertia condenser rotor. But they do possess slip-rings and brushes, which are unloaded except for brief and infrequent starting periods. This invites brush trouble. The normal squirrel-cage motor is inadequate as to thermal storage to start a large condenser. To solve this problem a new squirrel-cage motor was developed. It has no rotor winding in the conventional sense, being a solid forging. Axial grooves cut into the surface increase the torque in the zone of 20 to 50 percent slip.

Another unusual requirement for a large motor was one for service in an aviation laboratory. It may be required, for example, to drive a propeller undergoing test in the super-hurricane of a wind tunnel. Maximum capacity and small size are essential. The motor provided is only 36 inches in diameter yet develops 3000 hp for half-hour intervals. It is a two-pole motor operating on a 120-cycle supply. The rotor is a solid forging with a cage formed by bars driven in slots cut in the steel. Retainer rings of high strength were obtained by employing Discaloy, a metal developed primarily for jet-engine disks.



D—A novel starting motor for a condenser is mounted within the hydrogen enclosure. E—One of several hundred 600-hp a-c motors of unusual efficiency.

High-speed motors for powerhouse service are getting bigger. Two-pole, wound-rotor motors of 1500 hp for this service are under construction. Two years ago these pages spoke of the top limit as being 750 hp.

Also more and more powerhouse motors driving draft fans are being required to have weatherproof housings for outdoor service. Also more draft fan motors at steam plants are totally enclosed, fan cooled.

No Peace and Quiet among the Fractionals

UNCOUNTED tens of thousands of types and varieties of fractional-horsepower motors have been designed in the past half century. One might expect that all the combinations possible or needed would have been produced. Far from it. Because of the growth of the industrial age, its increase in complexity, and the ingenuity of engineers, improved motors and new motors are produced at an unslackened rate.

Die-cast aluminum brackets have replaced the traditional cast iron with rather startling results. With die casting it is possible to make more ventilating holes; enough more that the drip-proof laundry-type motor (NEMA 56 frame) runs 18 degrees C cooler. That is equivalent to increasing the output by 50 percent. The die-cast brackets also make for smoother, more pleasing motor contours.

Because of the lighter weight of aluminum and because thinner sections can be allowed for machining, the weight of the bracket is reduced by two thirds, which drops the weight of the complete motor (NEMA 56 frame) from 24 to 20 pounds. Aside from other obvious advantages, such as lower casting cost and less machining, the weight reduction means a saving of 3.4 cents per motor in average shipping charges. Mere pennies? But on, say, 100 000 such motors this accumulates to $3400, a figure helpful in offsetting rises in costs of labor and materials.

While the costs of molds for die casting are 10 to 12 times those for iron casting, the costs can be justified from savings realized because of the large quantities of these fractionals.

More and more devices use a small amount of electric power. Electric typewriters, postage meters, office reproduction machines, and scores of calculators and other types of business machines now are common on the industrial scene. For this purpose an improved motor of the smallest size of standard NEMA frames (42) has been developed. It employs die-cast aluminum brackets. This reduces weight (important when machines using it are shipped long distances), and makes for greater appearance harmony with the remainder of the machine. A rubber sleeve molded to fit over a hexagonal bearing housing makes a convenient resilient mounting. Ordinarily a 1725-rpm motor of this frame size would be expected to develop only about $\frac{1}{20}$ hp. This newly designed motor, however, has developed as much as $\frac{1}{8}$ hp using die-cast aluminum open brackets. This is important as the space allowable for the motor is, more often than not, extremely limited. Even fractions of an inch are important.

A better motor has been developed for operating chain hoists. The single-phase capacitor motor used for this service is not inherently reversible by plugging, i.e., by reversing the terminals. Yet it must be reversed in a small fraction of a second in response to movement of the chain by the workman. The motor changes from full speed in one direction to full speed in the other in about 0.4 second. The usual way to achieve this reversal is to cut the starting winding back into the circuit until reversal is effected and then quickly remove it again. This is now accomplished by a new circuit and a new small relay. This is sealed in a metal can to give a simple switchless hoist motor almost free of maintenance requirements. The new circuit arrangement, furthermore, eliminates any possibility of the motor starting to move in the wrong direction because of failure to remove the starting winding after reversal has been effected.

A further improvement to small motors has come from dipping the stators in thermosetting varnish—the kind that was used with startling success as a protective coating on electric torpedoes. A single dip and bake in Thermoset varnish is superior to two treatments with the conventional resin varnish. The coils are much more rigidly held. With less coil movement fewer grounds and short circuits develop. The superior moisture resistance of the synthetic varnish adds greatly to the life of the winding in the presence of humidity. Also the varnish provides a better base coat for paint as it contains nothing soluble in the thinners commonly used in succeeding coats of paint.

New loom motors employ many of the Lifeline motor principles, including fabricated-steel construction and prelubricated bearings.

Low Cost Widens Variable-Voltage Usefulness

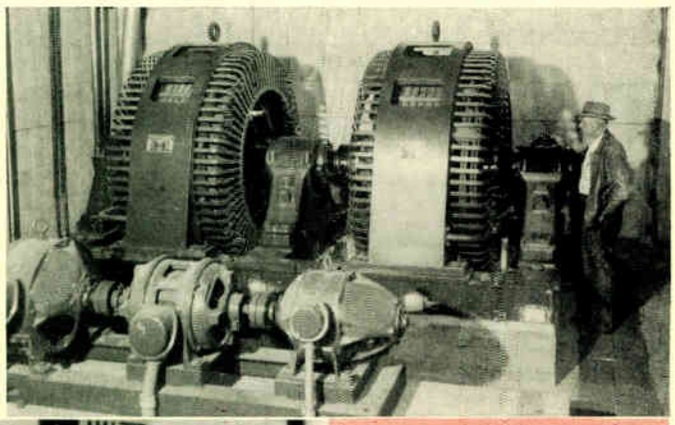
FOR MANY industrial jobs variable-voltage direct current has no substitute. The problem has been to get the variable voltage at low cost. About two years ago a packaged variable-voltage power supply (AV drive) appeared that greatly reduced that cost. It was an integrated design of motor-generator set and control planned for simplicity, compactness, and least cost compatible with the job to be done.

This drive has been remarkably effective. It has made possible the benefits of variable-voltage in many industrial processes where cost previously ruled it out. Among these are physical compactness, coordinated design of all components, d-c motor-speed ranges up to 16 to 1, regenerative braking, and the closer control of speed and load that results from use of an electronic exciter instead of a rotating one. The amount of wiring to be done as the machine is installed is greatly reduced.

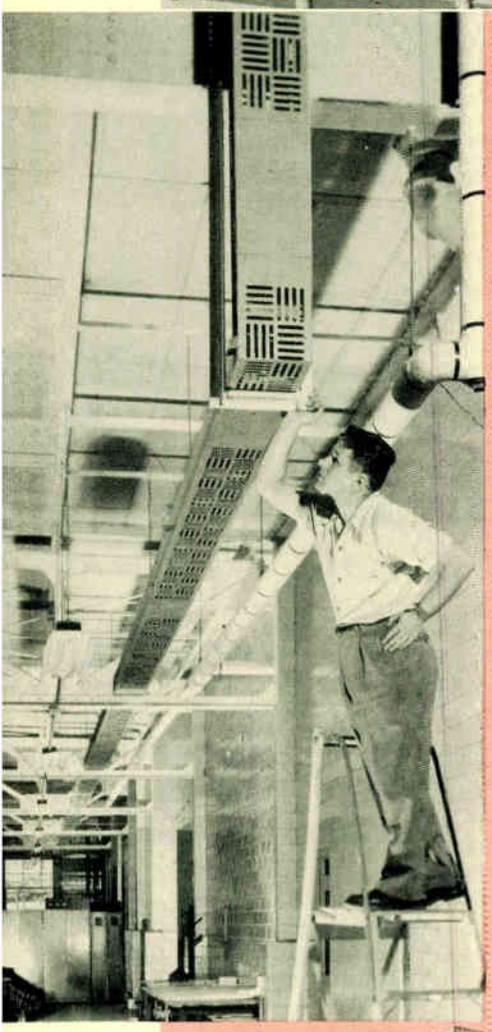
The field of the AV drive was widened last year by the addition of new ratings up to 100 hp. Previously the largest size of AV drive was 50 hp.

Contactor and Linestarters Are Modernized

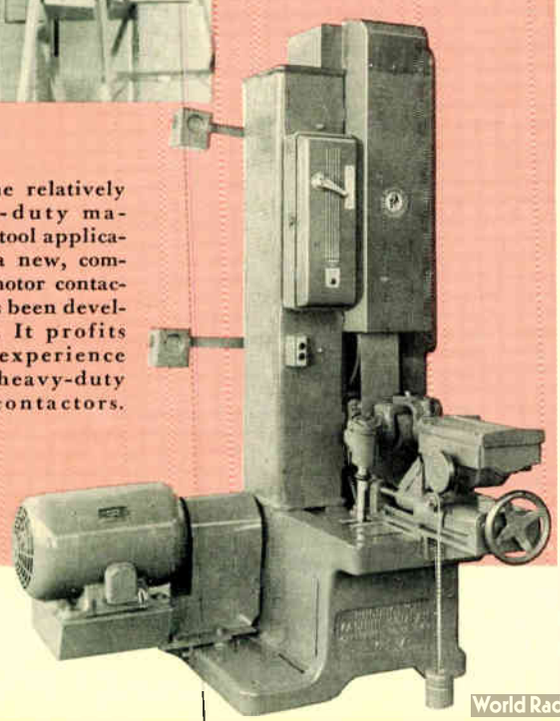
NUMEROUS improvements in contactors have appeared in the last 12 months. A modernization of contactors and Linestarters (type NR) that began during the war has been



At the Basalt Rock Co., a Rototrol rotating regulator is used to control heavy currents for butt-welding large steel pipe.



A low-impedance bus duct is designed specifically for feeder functions at currents up to 4000 amperes where low voltage drop is important. The drop does not exceed three volts per 100 feet at the worst load condition. The duct utilizes close conductor spacing, two or more conductors for each phase, and phase conductors not adjacent to each other. It is physically very small; it can carry twice as much current for a given cross section as the conventional plug-in type of bus duct.



For the relatively light-duty machine-tool applications a new, compact motor contactor has been developed. It profits from experience with heavy-duty mill contactors.

completed so that NEMA sizes 0, 1, 2, 3, and 4 are available. These are characterized by knife-edge bearings, which contribute least possible friction, the De-ion principle of arc extinction, and ease of servicing coils and contacts.

For heavy-duty d-c service, as in steel mills, improved contactors have been made available in ratings from 100 to 2500 amperes (type M). These, too, use knife-edge bearings. The efficiency of the arc interrupter has been improved by attention to details that bring about less burning of the contacts and arc box, thereby extending the time between servicings.

For lighter-duty jobs than those in steel mills new contactors have been developed (MM). Based on experience with the 25- and 50-ampere ratings, the 100-ampere size was developed. By careful use of heavier parts the new 100-ampere contactor is essentially no larger than previous 50-ampere d-c contactors. This compactness is highly desirable on machine tools where space for controls is always scant. These contactors are available in the various combinations commonly used, either spring or magnet closed.

Motor Sentinel Starters

A NEW, SMALL, rugged motor starter, the Motor Sentinel, has been developed jointly by Bryant Electric and Westinghouse. This unit is a one- or two-pole starter and protective device for fractional-horsepower motors.

Considerably reduced in size, the new Motor Sentinel has been simplified and is more rugged. Thermal overload protection is provided by a bimetallic unit in conjunction with a heater. The bimetallic element is preset at the factory for the starter and does not have to be changed. The heater is easily accessible and can be quickly removed and replaced from the front without removing the switch unit from its enclosure. For a change in motor full-load current, it is necessary to remove only two screws and exchange heaters. Quick-make, quick-break contact action is provided by the over-center toggle mechanism. The handle is trip-free and indicates clearly whether the switch is *on*, *off*, or *tripped*.

The unenclosed switch unit is compact and can be installed in a standard wall box. The standard enclosure is made of die-cast aluminum. The water-tight, dust-tight, and explosion-proof enclosures for these switches are fabricated of cast iron to ensure tightness.

AB Breakers for 575-Volt Mining Service

THE USE of long current paths for transmitting d-c power to the utilizing equipment in various mining applications introduces a high inductance into these circuits. And in interrupting these 575-volt d-c loads, ordinary circuit breakers have not been able to extinguish the arc formed. Because of the inductance the arc hangs on more persistently even with the conventional blowout coil and de-ionizing structures.

A new 575-volt AB breaker for this particular mining service has been developed. The new breaker is capable of interrupting 2000 amperes at 575 volts in an inductive circuit of five millihenries. This breaker utilizes the blowout coil and De-ion arc-chute principles, but the blowout coil forces the arc onto special cooling plates having a high chromium content. The arc is cooled rapidly and, in combination with the De-ion grids, it is extinguished easily and rapidly. The AB breaker for this service is no larger than the standard AB breakers used for ordinary applications.

Microsyn—A Precision Regulator

Do you have need of detecting position deviation as small as 20 seconds of arc? (In a hundred yards that is only one-third inch.) Or perhaps you wish to turn a shaft with corresponding precision. These and similar precise functions can be done with a new type of device, known by the general name of microsyn, the basic idea of which was produced by the Instrumentation Laboratories of the Massachusetts Institute of Technology. This is a precision device—and entails the cost of such—developed originally for military applications, but it has intriguing industrial potentialities.

It consists of a moving element within a four-pole field—which clearly is not new—but because of its precision construction new things are possible with it. The magnetic structure is of Hipernik specially processed to give a hysteresis loop of least area, and a permeability of 100 000 with 0.03 oersteds coercive force. Furthermore, the process provides a magnetic alloy extremely consistent as to characteristics. The microsyn requires extremely accurate dimensional control. All ground surfaces are accurate to one tenth mil.

The microsyn as a regulating device is superior to step-type regulators in that it produces results in infinitesimal steps. Also it is far more sensitive and accurate than devices of the Synchro-tie or Selsyn type. In brief the microsyn can do three kinds of things: (a) it can produce a voltage proportional to turning the rotor over a range of plus or minus 10 degrees, with a sensitivity of 20 seconds; (b) it can produce a torque that is linear with the square of a signal current; and (c) it can act as an elastic restraint generator, producing a torque proportional to the product of the square of a current and the angular displacement.

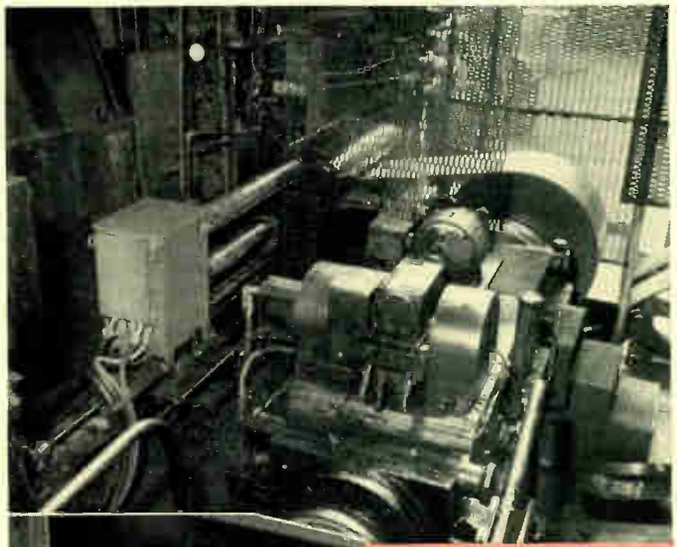
The microsyn can be considered a basically new device, now in its infancy, but about which a great deal will be heard.

The Rising Star of Magnetic Amplifiers

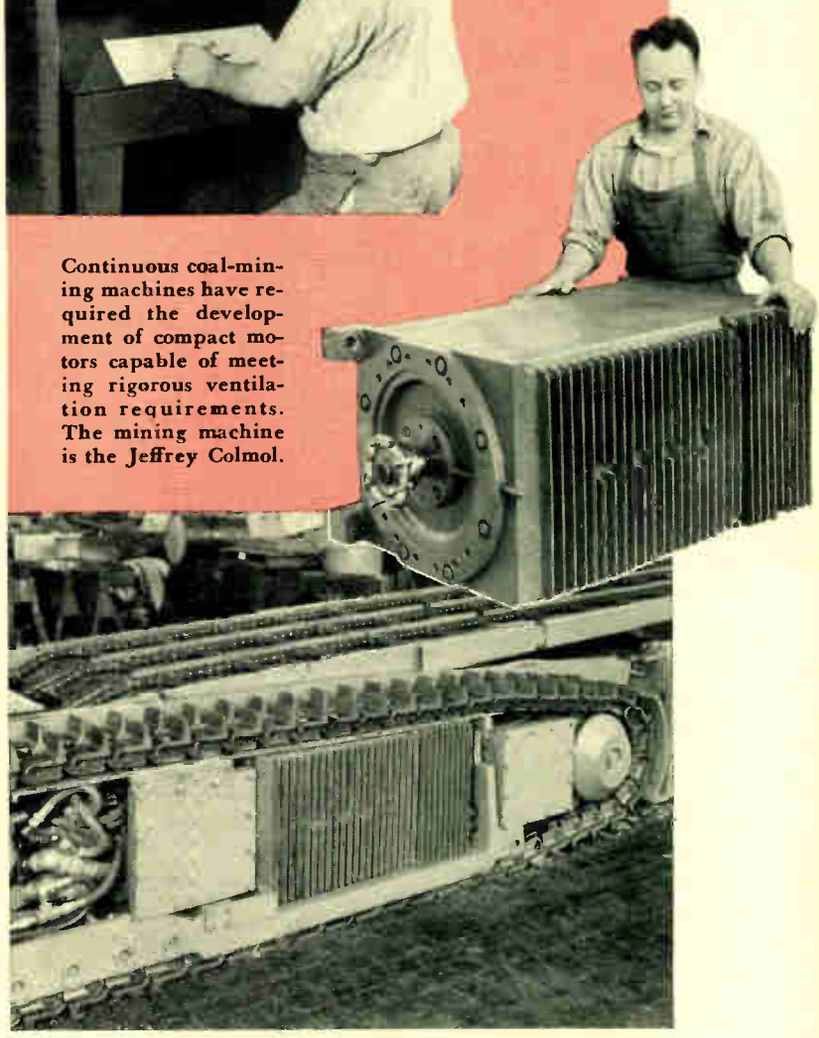
Until three or four years ago, electronic tubes had a virtual monopoly in the field of high amplifications. Then magnetic amplifiers—curiously, a device older than tubes—arose to challenge this monopoly. Since then magnetic amplifiers have grown enormously in popularity and every day new uses arise. A magnetic amplifier avoids the disadvantages of a tube in having no filament, vacuum, or vacuum seals, etc. But, being an inductive device, it does not respond as rapidly, i.e., it has a much longer time constant, such as tubes that have the advantage of employing relatively weightless electrons in a gas.

A large improvement in magnetic amplifiers came last year by way of a new core material. It is a new form of Hipernik (Hipernik V), the high-permeability electrical iron produced by Westinghouse Research Laboratories in 1924. While the new material has essentially the same composition, it is processed differently to produce a strong grain orientation. Annealing is carefully done to ensure that grains are neither too large nor too small.

The purpose of such careful processing is to obtain a magnetic material with a hysteresis loop that (on the B/H magnetization curve) is a narrow vertical rectangle. This gives the material a nearly linear amplified output over a broader range. This spells high sensitivity and more output per pound of core material. Hipernik V saturates at about 16 000 gausses. Most other irons used in magnetic amplifiers saturate at about half that. Makes them bigger.



The x-ray thickness gauge on a cold-strip mill (above) gives a continuous reading of strip thickness to the mill operator (left).



Continuous coal-mining machines have required the development of compact motors capable of meeting rigorous ventilation requirements. The mining machine is the Jeffrey Colmol.

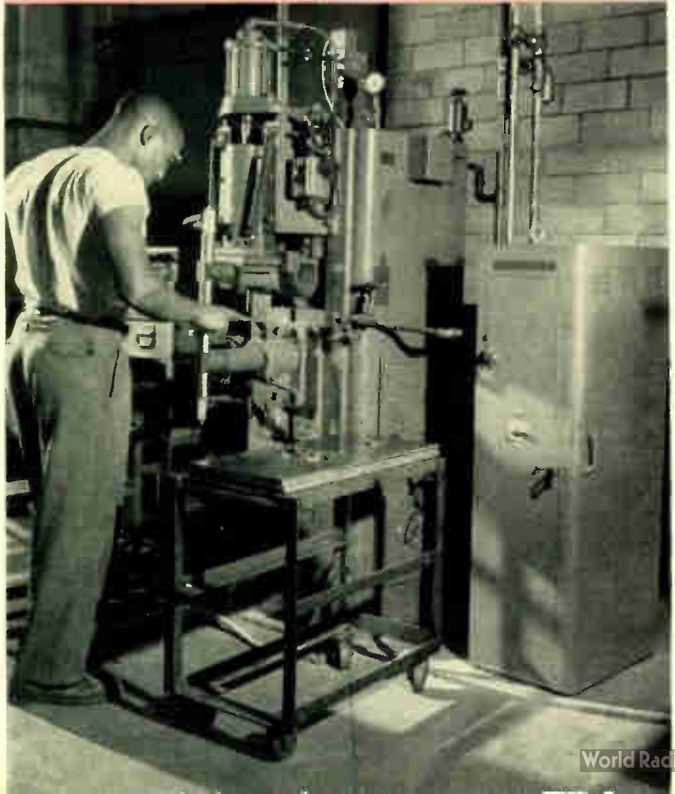
High-performance magnetic amplifiers are built from Hipernik V gapless toroidal cores wound with coils composed of many turns of copper wire. Equipment has been developed to wind the cores spirally from Hipernik V tape 0.001, 0.002, or 0.005 inch thick. Since the core must later be annealed at a temperature above 1000 C, the strip is coated with a refractory coating before winding so that the turns of the core are physically separated during annealing to prevent welding into a solid mass. After annealing, the core is strain sensitive, necessitating enclosing the core in a hermetically sealed Nylon or Micarta case so that the copper windings will not apply stresses to the core. Equipment has been obtained for machine winding the copper coils on the cores, making possible quantity production of completed magnetic amplifiers in an integrated setup with consequent cost reduction.

Measuring on the Run, without Contact

PAPER MILLS, whose goods flow from machines in an endless stream, have a special set of measurement problems. The need for making accurate measurements, and perhaps controlling accordingly fast-moving ribbons of paper, usually without physical contact, has fostered a variety of ingenious devices. Among the latest is a new edge regulator for use on paper and cellophane winders and slitters.

This regulator uses a new-type photoelectric scanner developed to regulate the position of large rolls of paper on which are being printed multicolor designs for subsequent packages. In the new scanner, a small, contact-less vibrator takes the place of the synchronous motor previously used. This reduces size and eliminates a rotating part. Fewer adjustments are now necessary. By comparison with previous phototube scanners, the new one is able to provide an increase in torque so that larger rolls of paper can be regulated or, if preferred, a twice-faster correction rate can be had. The new control also has the advantage of giving no correction if the paper is removed, or if the line or edge is lost by the scanner because of too rapid deviation.

Resistance welding with new functionalized control.



Fast, Accurate Shears

CONSIDER the problem of wielding a knife on a strip of material moving at various speeds up to 200 feet per minute with such precision that each piece is within one-eighth inch of the same length. This is the problem in mills producing galvanized sheet for roofs. The old way had been to use a continuously rotating cutter so geared as to make one cut each revolution. But this was an expensive device, and involved a gear change each time a different length of cut was desired.

Now an electronically controlled cutter does the job. A phototube is set on the far end of the table a certain exact distance short of the length of galvanized sheet desired. When the end of the sheet arrives, the phototube gives the signal to the cutter motor, which starts, makes the cut, and stops in precisely the original position, waiting for the next cutting signal. This shear can be varied to make accurate cuts of different lengths and for different production speeds.

Another control, not electronic, has been built for a flying shear to cut moving aluminum rod. The motor is connected directly, without gears, to the shear. When given the signal, the motor starts from rest and in about one fifth of a second and one third of a rotation reaches the speed of 190 rpm, corresponding to 800 feet per minute of the moving strip. The knife connected to it makes the cut and the motor must then decelerate to a precise stop in the remaining two thirds of a revolution ready for the next cut. Most of the last 120 degrees rotation is made at slow speed to permit stopping at the exact spot required. Cuts are made within four inches accuracy with aluminum moving 700 feet per minute.

A Rototrol Regulator—Welding "Switch"

ONE HARDLY thinks of a Rototrol regulator as a contactor. But it can be used as one.

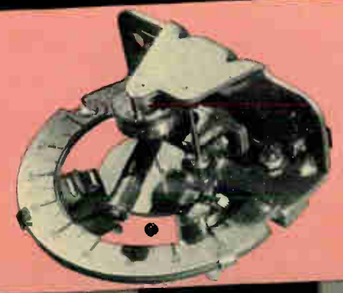
Basalt Rock Company make large diameter, butt-welded pipe. Single-phase current passes through welding wheels that roll across the joint and, by resistance, heats the joint for welding. Current is supplied by a three-phase to single-phase 1500-kva motor-generator set. To waste least possible pipe it is desired to start the current as quickly as possible when the welding wheels make contact with the leading end of a pipe-to-be. Also the current must be reduced to a low figure just before the wheels break contact at the end of a completed pipe to prevent arcing. A large a-c contactor for this frequent service would be both expensive and costly to maintain. The "switching" is done by the Rototrol regulator that acts fast to force the generator up to its preset welding current output at the start of a pipe and equally quickly forces it down again just before the wheels leave the far end. This scheme has been used before with success, but never with so large a welding machine, and usually at 180 cycles instead of 60. The equipment is furnished by Yoder Co., utilizing Westinghouse electrical apparatus.

Super-Drive for Supercalenders

THE SMOOTH, good printing surface required on most paper in quality books and magazines is obtained by calendering—ironing, if you please. The paper is fed from one reel, through a series of smooth rolls bearing against cotton or paper rolls that apply the calendering pressure, and is wound on another reel. A new supercalender drive does this better,

IN PICTURES— *a progress report*

The synchronous-motor timer used in high-speed distance relays is improved in appearance and reduced in size. Also it is considerably sturdier.

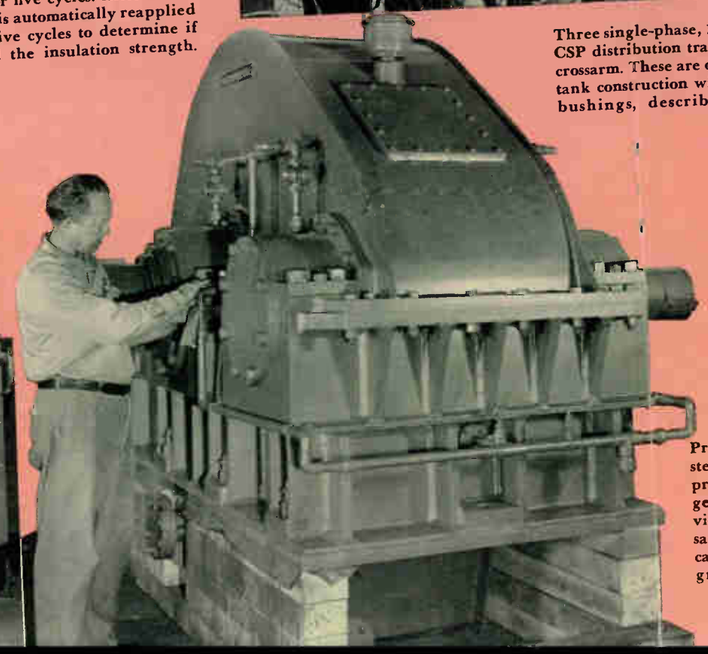


A-C power plant for passenger cars is a draw-out unit. ↓

Here ceramic materials undergo their trials by arc. A new test bench makes possible arc-erosion tests on ceramics and similar materials. A 500-volt, 500-ampere arc is applied for five cycles. After a wait of 30 cycles, full voltage is automatically reapplied for a second period of five cycles to determine if the arc has diminished the insulation strength.

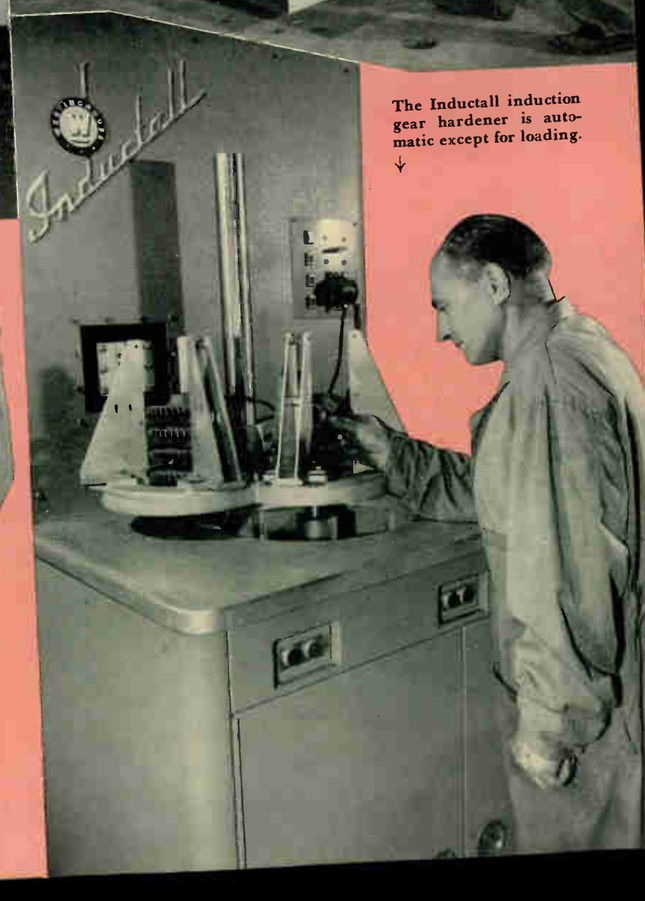
Eight-step voltage regulators for distribution circuits in production. (Story p. 12.) ←

Three single-phase, 10-kva, 4160-volt CSP distribution transformers on one crossarm. These are of the new round-tank construction with wall-mounted bushings, described on page 11.

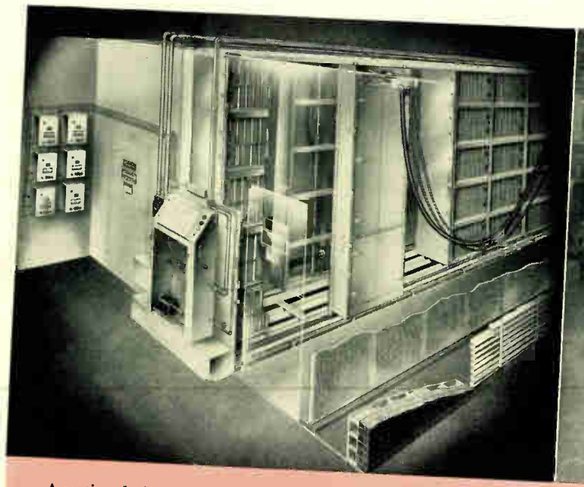


The 90-watt fluorescent lamp with krypton-argon gas produces more light than the argon-filled 100-watt fluorescent lamp. →

← Precision gears cut from heat-treated steels are substantially smaller than previous gears. In one case an 85-inch gear was able to do the work of a previous 120-inch gear, and led to other savings in the complete drive. Gear cases fabricated of structural steel give greater rigidity than cast cases.



The Inductall induction gear hardener is automatic except for loading. ↓



A sectional view of a semi-automatic washer for a Precipitron air cleaner of the type used in large industrial plants.

One section of the control equipment of a new tandem cold mill that is part of France's expanded steel-making facilities.

initial service test was made the rated capacity of 350 tons of material per hour was well exceeded without a hitch.

Unusual Motors for Continuous Mining

THE undercut-drill-blast-load technique of mining coal is being challenged by the powerful continuous mining machines. They literally chew their way through a coal seam; cutting chains or augers break and cut the coal as the machine advances into the face like a giant mole. Simultaneously, the loosened coal is conveyed back over the machine and taken out of the mine.

These remarkable machines have required new types of electric motors to drive them. Externally they look like anything but conventional motors. They resemble nothing but a rectangular steel box. sometimes with corrugations or ribs on two sides. Only a shaft protruding from one end suggests what might be inside. The big problem, as might be expected, is lack of space. Designers of continuous mining machines need high-power outputs packed into unbelievably small space. Furthermore, the motor must be explosion resisting.

Two varieties are being built. One is air-cooled, the other water-cooled. A common air-cooled motor has the corrugated sides to facilitate heat dissipation. In a rectangular case, 18 by 24 by 34 inches, is packed 50 hp. Silicone insulation is used on the motor windings. Engineers plan to build one for 100 hp.

The water-cooled variety is, naturally, smaller. The shape is similar but 60 hp is obtainable in somewhat less volume than the 50-hp, air-cooled. This motor has a built-in heat exchanger. It consists of finned copper tubes through which passes a stream of water on its way to the coal face for wetting down the coal to minimize dust.

Fresh Water from the Sea

WATER SHORTAGES that have been getting headline attention in the United States are nothing as compared with those in other parts of the world. Areas bordering on the Persian Gulf, for example. Here the rainfall is only about four inches a year. (The desert in Southern Arizona gets about 8 inches.) When wells are dug the stuff that comes out, if not oil, is brackish water. Water for some cities is transported long distances by ships or tank cars. The sight of water carried by mules and camels and being sold by the cupful from goatskins is not uncommon.

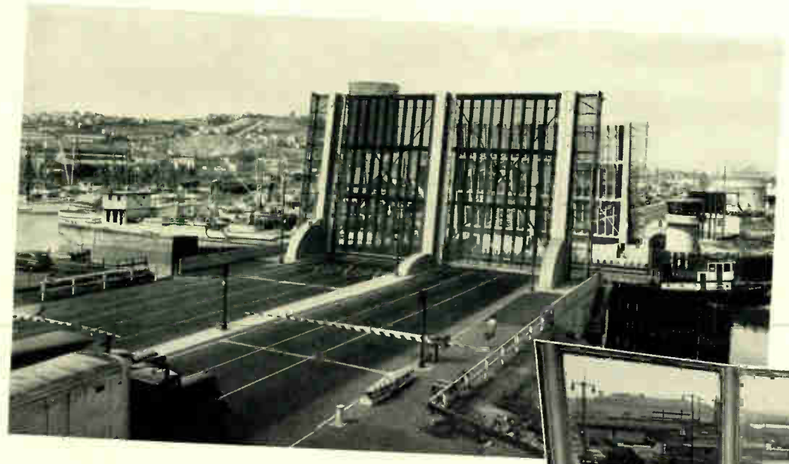
Companies developing the rich oil lands have a serious problem in supplying their working communities with potable water. The Kuwait Oil Company has one interesting solution—it makes it out of sea water. Natural gas is plentiful and cheap. This gas is burned to supply steam for use in a novel type of Westinghouse distillation plant to produce fresh water that can be used to dilute brackish well water.

A series of three evaporators and one condenser comprise a unit. By performing the evaporation in three steps instead of the normal one, using the heat in the vapor of one as the energy source for the next, and by employing other Btu-conserving tricks, more than 2½ pounds of fresh water is obtained for each pound of steam. (With the single-step distillation process the output is not over pound for pound.) The six units provide 720 000 gallons of fresh water daily.

His Highness, Shaikh Abdulah, whose capital is the city of Kuwait, visited this installation and decided that it was the way to obtain potable water for his water-impoverished city. He has ordered six such installations. This system, furthermore, is not of interest solely to the arid regions. One United States firm, on a river that becomes brackish during periods of low stream flow, requires water of a certain minimum quality for its manufacturing process, and has installed a distillation unit of this same type.

New Tricks for the Electroplater

THE TECHNOLOGY of electroplating has enormously increased in the last decade. But for all of that, much of it is still an art, not a science. It has long been known that a



Separate controls and position indicators, interlocking switches and indicator lights keep the operator informed of the functioning of the electrical equipment of San Francisco's Islais Creek Bridge. The bascule is driven by two 20-hp a-c motors.

provides higher production with a reduction in physical labor.

Ordinarily the drag on the unwind stand is provided by a friction brake, and the power to drive the windup stand comes from a slip-belt arrangement from the main drive for the calender rolls themselves. With this system the tension, during acceleration and deceleration and as the reels build up, is anything but constant. And friction devices inherently spell high maintenance and outage time.

Now both the unwind and windup are separately powered, much in the manner of skin-pass steel-strip mills. Furthermore, their action is interrelated so that during starting, running, and stopping—with the diameter of paper (and inertia) on each roll constantly changing—the unwind generator holds back just enough and the windup motor pulls just hard enough to maintain uniform, constant tension in the paper sheet. Also because the unwind braking generator can be operated at slow speed as a motor, threading the end of a new sheet through the calender rolls is enormously facilitated. No longer does it have to be cranked off by hand.

On this new supercalender the finished paper is wound onto a core that rests between two powered drums instead of directly onto a single motor-driven roll. With this method of windup the paper can be trimmed as it emerges from the supercalender and wound directly on the shipping core. On other drives the supercalendered roll is wound on mill cores, necessitating rewinding prior to shipment.

Tin-Flow Lines Move Faster

RADIO-FREQUENCY heating, which won its spurs in the war emergency to conserve tin, has served notice that it intends to keep them—even with a faster horse. The wartime tin-flow lines ran at 1000 feet per minute (1300 fpm maximum). They utilized 1200 kw of r-f energy. The new mills move at 2000 fpm (2500 fpm maximum) and are supplied with 1800 kw, r-f. No particular difficulties have been encountered in this increase of speed and power. It is interesting to note the short time available for heating the tin. The film of tin on the steel sheet must be brought to its flow temperature of 452 degrees F by raising its temperature about 375 degrees F in about a third of a second. At present 11 r-f tin reflow lines are in service or under construction, all with Westinghouse r-f generators and control.

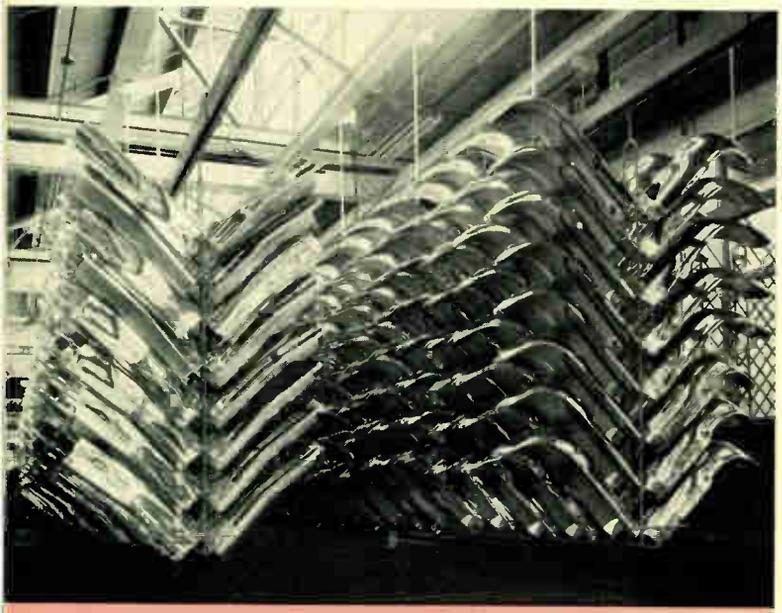
Single Operator Controls Underground Conveyor System

DUAL CONTROLS for airplanes or for practice automobiles are fairly simple and common. But quadruplex controls by which the different operations of a mile-long underground conveyor belt are controlled from any of four widely separated points without risk of error—that's something else again. This problem, as it arose at the Pend Oreille Mines and Metals Company Lead-Zinc property in northeastern Washington, illustrates the problems presented to control engineers.

In this mine the conveyor-belt system, when completed, will haul ore and waste alternately from four loading stations, at intervals, along a vein extending into the earth at slopes varying from 10 to 18 degrees. The principal control problems arise out of the requirement that the whole system of loading the belt with either ore or waste, operation of the conveyor motors to the surface, and the proper discharge equipment at the surface be controlled by a single operator from any of four loading stations. Obviously it is imperative that there be no risk of mixing ore and waste material, also that there be no piling up of material at any point.

A system of controls of the conveyor motors, with complete interlocking, was developed and tried on a miniature simulated system. Indicative of the complexity is the 47-conductor control cable required the length of the system. When the

(Continued on p. 22)



Bumpers for the Oldsmobile "88" obtain superior corrosion resistance by electroplating methods using Wes-X addition agent.

"pinch" of this or that added to an electroplating bath greatly improves the product, although the mechanism is not fully understood. Electroplaters sometimes facetiously refer to these addition agents as "snake oil."

A particularly efficacious addition agent (termed Wes-X) was announced last year. Added in small doses to cyanide copper-plating baths, the plated copper is smoother, is less grainy, and can be laid down at a faster rate. (By the way, the corrosion-resistant layer on many of the plated-steel products is copper. An outer layer of nickel follows the copper for additional corrosion resistance, followed by a flash of chromium, which is applied almost entirely for eye appeal and tarnish resistance.)

The arrival of Wes-X addition agent is particularly timely. The trend is to thicker layers of copper, to provide better corrosion protection. But with the conventional cyanide electrolytes, thicker copper plate became too rough, too grainy. Use of cyanide-copper electrolyte seemed to be lessening, to be replaced by the acid-type electrolyte. With Wes-X addition agent heavy, smooth deposits of copper are now being produced in the cyanide solution.

Among addition agents Wes-X is unique. It utilizes an inorganic metallic salt as a base instead of an organic one. The baths are much more stable with this inorganic Wes-X agent because no decomposition products build up, as occurs with organic agents, causing low-quality deposits. The Wes-X addition agent is applicable to both conventional and periodic reverse-current plating techniques. It greatly improves the quality of the copper plate and the rate at which copper can be plated by either technique.

A new development has also been made in the brass-plating field. Brass plating is highly desirable for some decorative purposes and absolutely essential as a coating for steel to which rubber is to be applied—such as wire for tire casings. But brass plating has not been a highly efficient process—only about 50 percent. This disadvantage of brass plating has been removed by a fundamental change in the electrolyte used. The efficiency has been raised to 100 percent and bright, heavy deposits are now obtained.

Better Controls for Resistance Welding

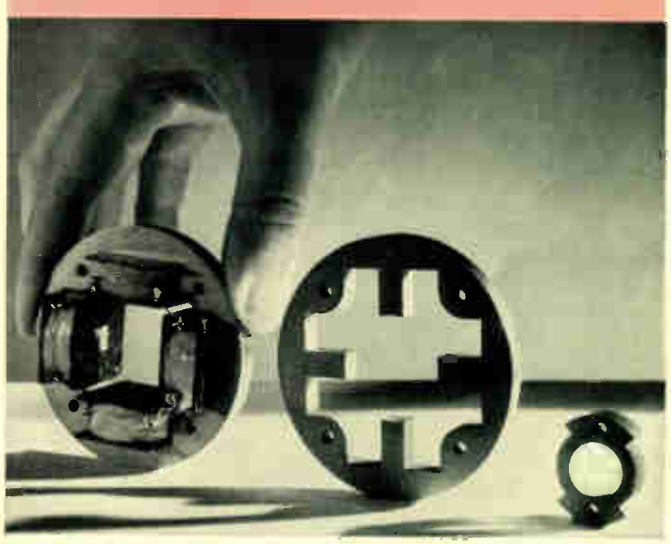
With manufacture of aircraft again greatly on the increase, the ability to weld thick aluminum sheets assumes new importance. Resistance welding of aluminum is difficult because its great heat conductivity allows the heat to flow away so fast that poor welds may result. When the war ended in 1945, the thickest aluminum sheet that could be resistance welded and meet rigid specifications of strength, consistency, and freedom from cracks was not much more than $\frac{1}{16}$ inch (0.070). Recently the Thomson Electric Welder Company, using Westinghouse three-phase, low-frequency controls, has welded $\frac{1}{8}$-inch (0.125) thick aluminum experimentally.

During the war, whenever a new control function was desired, a whole new welding control was developed specifically for it. It became obvious that consolidation and unification of designs were necessary. Many welding controls whose functions were similar had nothing in common with one another—circuits were different, size was different, and method of construction was different. In 1945, the first steps were taken to obtain unified or "functionalized" design. The required functions were physically separated from one another in design and construction. Each electrical function was made into a panel entity. In other words, each main function like spot timing, pulsation timing, heat control, current regulation, etc., were put on individual panels capable of being slid into a cubicle. By combining various types of panels, virtually any type of sequencing, regulation, or timing systems could be achieved from a few panels. Today there is virtually only one type of resistance-welding control, but there are several functions available within this control.

In addition to functionalizing the controls, the size has been reduced. The height of the new units, the floor space required, and the area taken by electrical components have been reduced to about half that needed by older units. In addition, virtually all parts that wear (such as relays) have been eliminated in favor of electronic tubes. The precision and speed of the most inexpensive 1950-model welding control exceeds that of the highest priced 1940 models.

This present stage of control development has also produced another type of welding system—the low-frequency

The microsyn is a new type of control element. It is a highly sensitive and accurate position-responsive device.



converter. Here three-phase or single-phase power at line frequency is converted electronically into a low-frequency single-phase source, which is fed into the secondary of the welding machine. At low frequency (between 5 and 12 cycles per second) the reactive effect of the welding transformer is nullified and consequently the kva demand reduced. If the converter is a three-phase control, it is, of course, possible to spread this reduced demand over three phases. This type of welding system today has become so important that all welding jobs requiring low-kva demand use the three-phase, low-frequency converter system. It has superseded the capacitor energy-storage system, the magnetic energy-storage system, and has virtually superseded series-capacitor systems.

A D-C Welder without Moving Parts

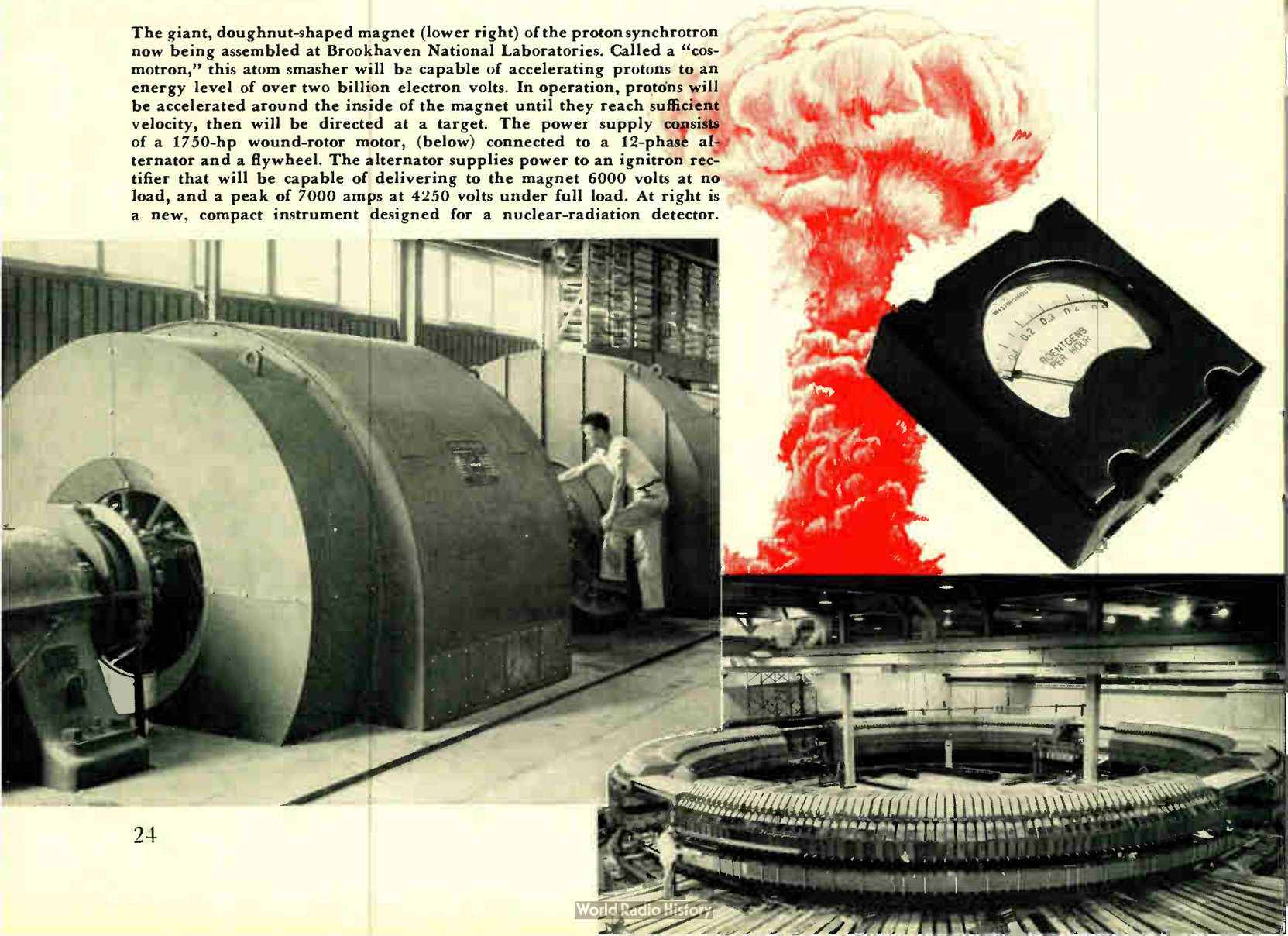
TWO TYPES of power have long courted the favor of Miss Arc Welding. For many years direct current had had the best of it—in fact until about four years ago it has the field essentially to itself. Alternating current, although possessing many sterling qualities of efficiency and absence of rotating parts, struggled with many technical difficulties. Then a transformer-type welder arrived. It has enjoyed great popularity ever since, stealing some of the motor-generator set's thunder. Now, however, a new form of d-c welder has appeared. It is enjoying phenomenal popularity for arc welding. It has shed most of its awkward qualities. In fact, in general appearance the a-c and the d-c welders now look much alike. Both have nicely rounded cabinets, shaped not unlike a water cooler on wheels.

The d-c welder takes power from the a-c line, a selenium rectifier effecting the conversion. With a small fan, the only rotating mechanism to consume power when idle, the welder has high efficiency. It is quiet and has no rotating parts to require maintenance. It is built in five ratings: 200, 300, 400, 600, and 800 amperes. The 300-ampere unit weighs but 510 pounds, which compares with 1278 pounds for a comparable motor-generator set.

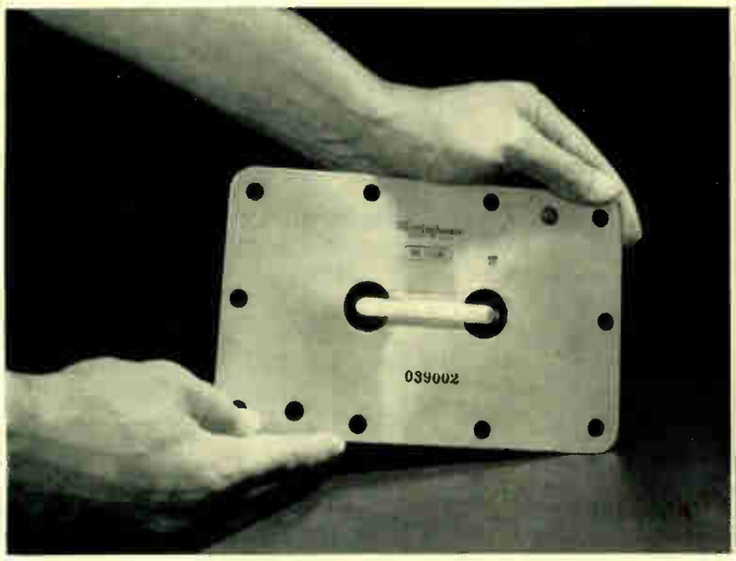
Probably neither a-c nor d-c arc welding will achieve a monopoly over the other. Both have their places. One interesting possibility of the rectifier welder is on large construction jobs where power is supplied from conveniently located engine-driven alternators at a voltage high enough to minimize loss.

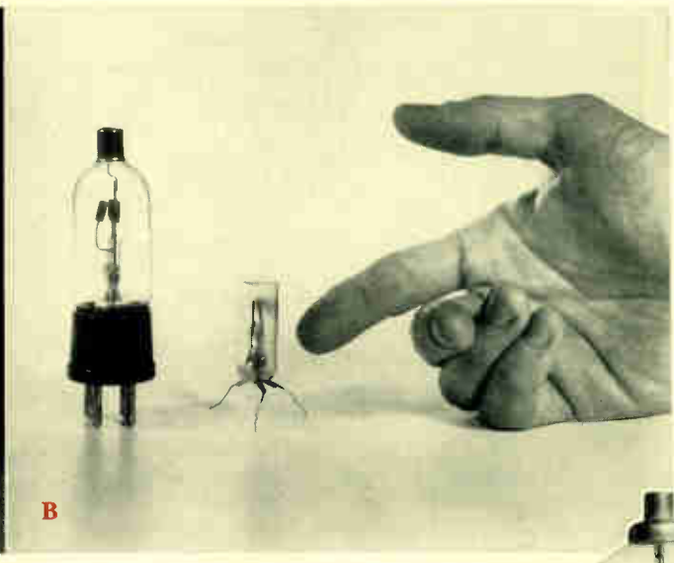
New Work for Selenium Rectifiers

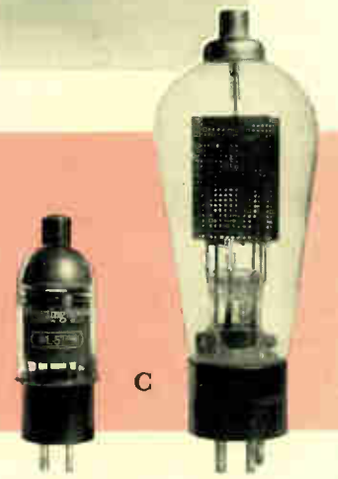
THE FAST-rising selenium rectifier has recently found itself doing two new and opposite jobs. One is to remove particles, the other to create and use particles. Both are applications of high-voltage electrostatic precipitators. As tin plate is manufactured the sheets are coated with a film of protecting oil. But the film must be uniform. Also, the thinner the better. Some mills achieve this by creating a fine oil mist and depositing it on the plate electrostatically. This requires a d-c potential of 70 000 volts for the precipitator. It is provided by stacks of selenium cells. The transformer and the selenium



The giant, doughnut-shaped magnet (lower right) of the proton synchrotron now being assembled at Brookhaven National Laboratories. Called a "cosmotron," this atom smasher will be capable of accelerating protons to an energy level of over two billion electron volts. In operation, protons will be accelerated around the inside of the magnet until they reach sufficient velocity, then will be directed at a target. The power supply consists of a 1750-hp wound-rotor motor, (below) connected to a 12-phase alternator and a flywheel. The alternator supplies power to an ignitron rectifier that will be capable of delivering to the magnet 6000 volts at no load, and a peak of 7000 amps at 4250 volts under full load. At right is a new, compact instrument designed for a nuclear-radiation detector.







A—A cigarette-size sealed-glass tube, fastened in a slot in a metal plate, gives protection to a radar receiver during pulse transmission. B—A new thimble-size radiation detector tube compared with the previous tube. C—A gas-filled thyratron compared to a mercury-vapor thyratron of similar rating.

rectifier are immersed together in oil in a single, compact tank. The rectifier stacks are made up of the new high-voltage selenium cells.

The other application occurs in ore smelters where the roaster, converter, and reverberatory gases are passed through Cottrells to precipitate the dusts. The new way of providing the high d-c potential, instead of the old rotating spark gaps with their high maintenance, radio-interference problems, and low efficiency, is a selenium-rectifier power pack. The voltage required in treating smelter dusts runs from 25 to 75 kv depending on Cottrell treater design. Selenium power packs are available to suit any voltage condition up to 100 kv. Because of the variable nature of the dusts that are transported to the Cottrell "treaters," arc-overs are fairly frequent. These arc-overs used to be cleared manually by reducing the a-c supply voltage below the arc-over potential. A new scheme using saturable reactors makes the circuit self-clearing and permits continuous operation at near the optimum d-c voltage. This fact coupled with a better d-c wave shape (much lower ripple value) results in more efficient dust collection.

The new type-H selenium cells, having a voltage rating of 33 volts per cell (instead of the customary 22 to 26 volts), give a rectifier that is smaller and lighter in weight than could previously be built. Such high-voltage rectifiers would be impracticable to build with copper-oxide cells, because of the great difference in the size of tank that would be required.

For military applications where moisture, salt spray, and corrosive atmospheres present a problem, selenium rectifiers are given the Fosterite treatment, developed during the war for airborne electronic transformers. An idea of the improved protection resulting from Fosteriting is obtained in the salt-spray test. Where most protective coatings have difficulty passing the usual 200-hour test, Fosterited stacks have withstood 1200 hours of salt spray with no electrical change and no visible deterioration.

Air Cleaning Made Easier

A NEW VARIETY of Precipitron air cleaner has appeared. While larger in capacity than the home unit, it is much smaller than is required in most factories and large buildings. It is useful where a volume of cleaned air from 1330 to 8000 cubic feet of air per minute is required. One is installed in a bakery, for example, over the area where vegetable oil is sprayed on pastries. It eliminates the nuisance of the oil mist in the surrounding atmosphere. The unit is small enough to be ceiling mounted, and hence occupies no valuable floor space. The air moves vertically through it. For this unit the various elements are built into compartments that slide in and out like file drawers. This makes removal of any section for servicing or repair relatively convenient.

The cleaning of large industrial Precipitron units has been simplified and made more automatic. These installations usually consist of vertical banks of 3-foot wide units, 8 to 14 feet high. One vertical, 3-foot wide column is washed at a time by injection of water onto it from both sides simultaneously by washers that travel on rails across the face of the bank. It is necessary for the service man only to initiate the operation at each column, 30 minutes later moving it to the adjoining column. The washing—which covers the ionizing section as well as the collectors—is done automatically, followed by drying and application of adhesive. It then stops.

One new power pack for the commercial and industrial Precipitron replaces the two ratings of power packs previously required. A saturable-reactor system holds the output voltage substantially constant for all loads. Because the voltage no longer rises on light loads, ozone production is less, and flashovers of dirt on the collector plates are reduced in frequency. The capacitors in the power pack are in a separate ventilated compartment so that the capacitors are not subjected to the heat produced by the transformer and resistor. The entire power pack is smaller and weighs less, and benefits from the advantages of higher production since one rating replaces the two sizes previously used.

New Tricks in Vacuum Tubes

THREE OR FOUR examples serve to illustrate the great variety of recent developments in electronic tubes. Old tubes are made more powerful or smaller, or both; entirely new tubes are built to do new things. In at least one case we have a device that an electric-power man finds difficult to believe is a tube at all.

Among the everyday variety of industrial tubes is a new thyratron. Instead of being a mercury-vapor tube it is gas filled, which makes it insensitive to temperature changes. Although this tube is only about one half as large as the equivalent mercury variety, it delivers a peak current of 20 amperes with an average of 1.6. The ratio of the two is high, about 12, which is desirable. It can withstand some 12 times full-load current on short circuit for 0.1 second without damage. Also its warm-up time is very short—about ten seconds.

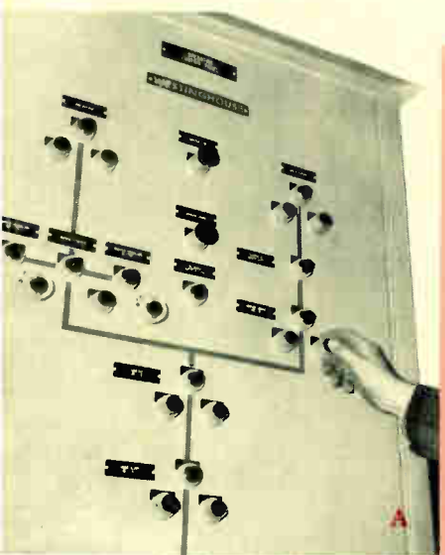
One difficulty in building gas-filled thyratrons has been the tendency for the vacuum to increase as the molecules are hurled into the anode and trapped. By new design methods and use of xenon, one of the heaviest of inert gases, the bombardment and hence the gas "clean up" as well as arc-drop losses are decreased. The same principles are being extended to amplifier tubes of larger ratings.

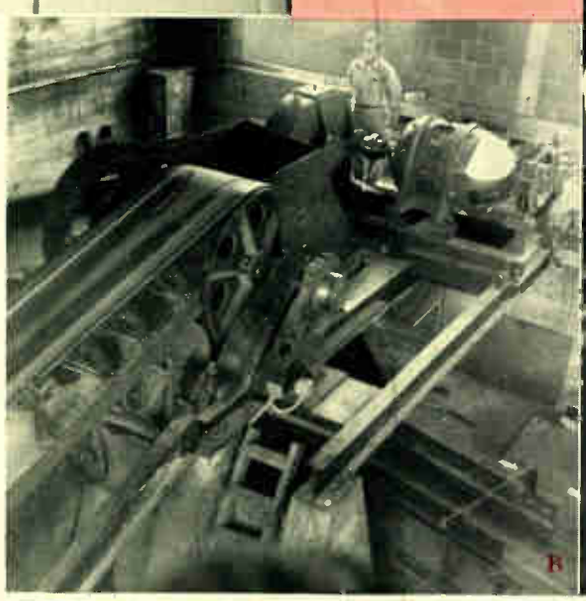
A high-power thoriated tungsten tube has been developed for broadcast and radio-frequency heating applications. Use of thorium-treated tungsten reduces the cathode power input for a given output in the ratio of 8 to 3, but this has not been obtainable before because of the difficulty of achieving sufficiently "hard" vacuums. The cooling problems are enormously eased. Oxygen is inimical to thorium, soon destroying its effectiveness. With better pumps, pressures of 10^{-7} mm are commercially obtainable (previous pressures were about 5×10^{-6}). The hum level, because of the lower filament current, has been reduced about 40 percent.

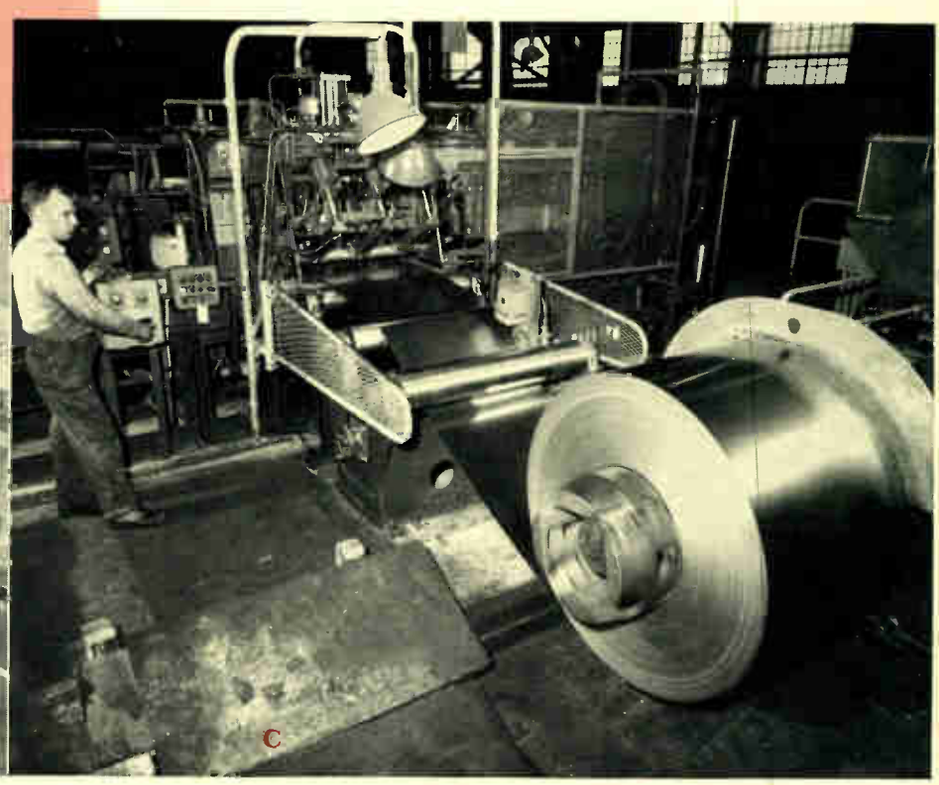
The need to provide tubes of least size for radiation detectors has shown what tube engineers can do. For one type of nuclear-radiation detectors the designers started with a trigger-tube (WL 759) in which a control current of as little as one micro-micro ampere (10^{-12}), between two electrodes, triggers a current of as much as one hundredth ampere (10^{-2}) in a third electrode. It is about three inches high and an inch in diameter. The new one (WX 3332) is the size of a sewing thimble. Furthermore this tiny tube can withstand mechanical shock of 1000 g.

Now the strangest tube of them all! It appears to be but a sealed-glass ampule almost identical in size and shape to a cigarette. In one form it appears to be empty; in another it seems to be filled with a cotton-like material.

None the less, it is a tube in that strange science—strange to power men, that is—of resonant-cavity devices, which delivers energy down hollow pipes. It is called a pre-TR tube and has a place in the radar scheme of things. It is mounted in a dumbbell-shaped opening in a thin metal plate that fits into the wave guide of a high-power radar set. It acts as a short circuit to spurious frequencies that would by-pass the narrow-band TR switch during signal transmission and damage the receiver that must be tuned to the low-power echo signals. How it is that a sealed-glass tube completely surrounded by a metal plate can act as a short circuit is beyond the ken of a man trained in 60-cycle electricity. But in the megacycle world things are different.







***A* and *B*—Control panel and one station of a single-operator controlled underground ore-conveyor system. *C*—In a mill that prepares coiled sheet for tinning, rough or damaged edges are trimmed off and the coil edge variation held to 1/32 inch with the strip running at 3000 feet per minute. This is accomplished by photo-electric edge regulators and suitable control of the two trimmer motors.**

A New Instrument for a New Age

IN THIS atomic age, the five senses with which man comes naturally equipped—sight, hearing, smell, taste, and touch—are not enough. He has had to develop another: the sense for nuclear radiation. Already the need is imperative around nuclear-energy piles and where fission products are employed. But should an atomic war develop, the lives of tens of thousands would depend on the immediate ability to sense atomic radiation, which does irremedial damage without giving warning of its presence.

The devices that provide this new sense are called radiacs. They comprise a detecting element, such as a Geiger tube, an amplifier, and a means of indicating the result to the eye or ear. This has called into being a new type of electrical instrument, developed by Westinghouse in cooperation with the military services. The instrument is new in its function but not in operating principle. It is essentially a microammeter. The scale reads in roentgens—another term added to lay language by the atomic age. The instrument has five easily selected scales of intensities. Turning a knob selects the proper amplification for each range and automatically brings into position the correct scale (in colors adopted as standard). Only one scale of numbers and a color can be seen at a time; thus, no error can result from reading the wrong scale. The instrument, made standard to fit all types of radiacs, is only three inches square, an inch and a half high, and weighs but twelve ounces.

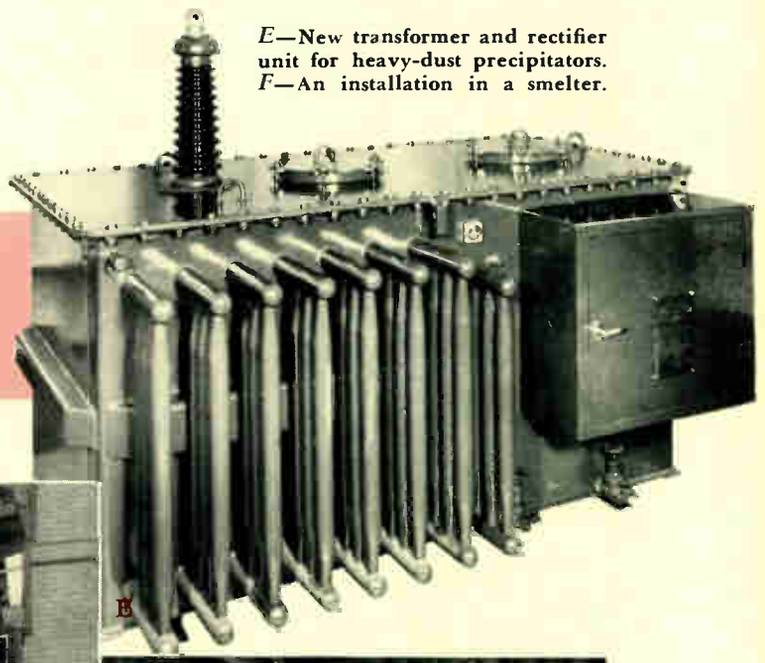
Important Advances in Switchboard Instruments

GREATER READABILITY—An instrument is no better than its readability. Most modern instruments are true masterpieces of the instrument-maker's skill. They are highly accurate and are resistant to adverse conditions, such as shock, vibration, and extremes of temperature. But the design skill that gives these results may be wasted under conditions of lighting or reading angle where the scale is obscured by shadows or by the surrounding instrument case.

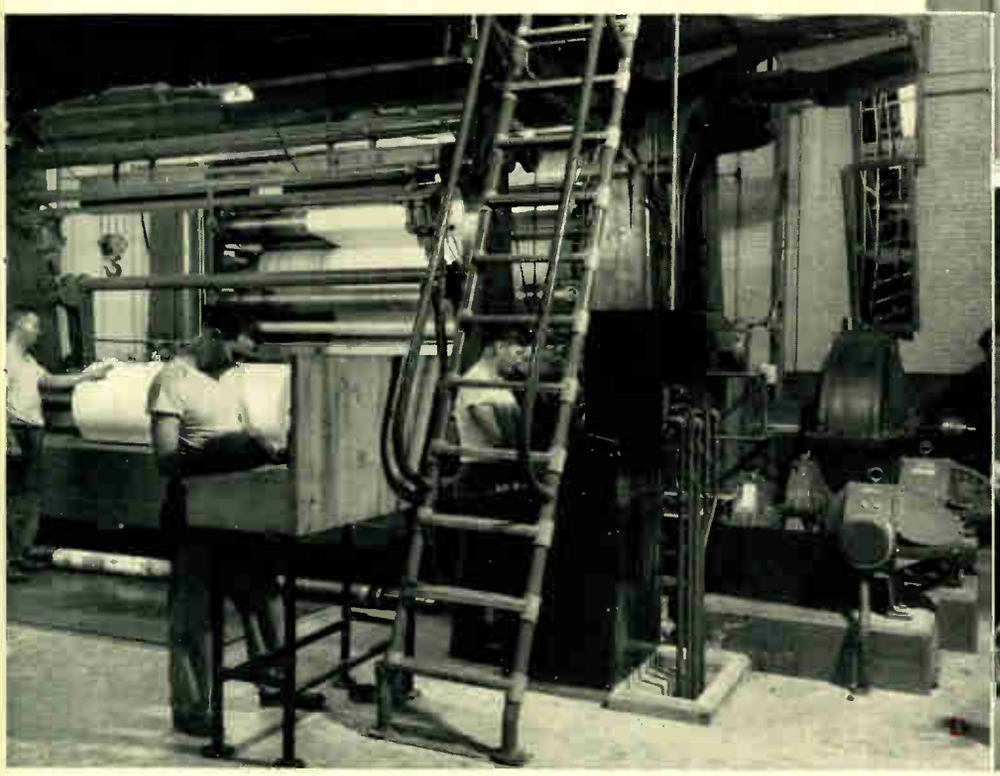
A recent development has introduced a major innovation in instrument readability. Known as the Full-View design, it is simple in appearance—in fact it has the simplicity of greatness. Actually, it is less complicated than the words needed to explain it.

A conventional instrument dial is a flat or stepped plate carrying calibrated markings or numerals. In front of this, sweeps the indicating pointer, and outside of that—about ¼ inch from the dial—is the glass window mounted in the frame or cover. It is this ¼ inch that frequently causes the trouble.

E—**New transformer and rectifier unit for heavy-dust precipitators.**
F—**An installation in a smelter.**



D—**The supercalender shown here has been equipped with the new drive described on p. 18. It is in a mill of the S. D. Warren Company in southern Maine. This is the mill, incidentally, that produces the paper on which these words are printed. It is a special, high-quality paper, given an additional processing to provide a non-glare surface.**



The fact that the frame is at least this distance from the dial may result in objectionable shadows or it may obscure the scale when seen from a sharp side angle.

In the newest development the dial is beveled just beyond the sweep of the pointer so the outer edge almost touches the window. The effect is surprising! It nearly doubles the angle of readability—it eliminates shadows on the scale regardless of the location of overhead lights—it gives the appearance of greatly enlarging the dial and makes the scale stand out clearly. It is a new concept for instrument readability.

Mechanism Improvements—The mechanisms of the entire Circular Scale family of instruments have been improved. In keeping with the trend toward more widespread application of this relatively new type of instrument, many improvements have been made to give better performance.

In the wattmeters and varmeters, internal insulation has been increased to provide for a ground test of 2500 volts rms instead of 1500—deflection of the pointer on voltage alone (i.e., even when current is zero) has been made negligible—the already high overload capacity has been increased. For the benefit of those users who mark their own scales to fit individual transformer ratios, the full-scale current spread has been increased.

In the d-c ammeters and voltmeters, means have been provided to adjust the scale distribution so practically perfect linearity is obtained—so half or full-scale current or voltage really comes at midscale and center-zero instruments have the same scale length on both sides of zero. For voltmeters or ammeters requiring self-contained resistors or shunts these components are easily accessible without opening the instrument.

From X-rays to TV

X-RAY-EQUIPMENT engineers sometimes find themselves involved in strange sideline activities. Last year they were busy with a television problem. They were asked to build a power supply—consisting of a few hundred watts of 80000 volts direct current—for theater-screen projection of telecasts, such as baseball games. Experience in the war building a similar but lower-voltage power supply for a naval application gave them the necessary background. For x-ray designers, 80 kv is low voltage.

Higher Powers for Broadcast Sets

IN GENERAL the maximum power of broadcast stations has been 50 kw, although a few of higher power have been built. Last year one was built for the armed services capable of 500 kilowatts output. It operates in the low-frequency part of the radio spectrum, below the commercial broadcast band. It thereby takes advantage of a powerful ground wave, which ensures communication to the desired areas unaffected by time of day or atmospheric conditions, as are systems relying all or in part on sky waves.

While the set is ten times greater in power output than standard 50-kw transmitters, it is physically only twice as big. This comes about from the development of a more powerful air-cooled amplifier tube, generous use of cooling air, and several other output-increasing technical features. The transmitter has its own power plant consisting of three diesel engines. The antenna will be about five miles long.

The "Voice of America" becomes louder by the installation in Austria of two 100-kw broadcast transmitters. These are essentially standard 50-kw sets, but the in-place amplifier normally held as a spare is also pressed into service. The two sets can be operated as a team to give a 200-kw signal when additional strength is desired.

New Work for Electronic Voltage Regulators

THE ELECTRONIC regulator is fast and sensitive. This brings to it many regulating chores that are out of bounds for other types of regulators. They are, on the other hand, custom built and, therefore, more expensive.

One new electronic-regulator task is the fast, exact control of the output of an m-g set supplying lamps for an accurate photographic printing process. It is desired to be able to add or remove any number of lamps without creating light flicker. The regulator holds voltage to within one tenth of one percent and acts so fast the generator voltage recovers from a sudden load change in three cycles.

Power companies sometimes have situations that make it desirable to regulate the magnitude and phase angle of station-bus voltages to eliminate circulating currents. On one eastern system, electronic regulators are used to govern the operation of voltage and phase-angle tap-changing transformers. The electronic regulators compare a local voltage with a voltage brought from a remote station over several miles of telephone-line wires. The electronic regulators are sensitive, accurate, and have a low volt-ampere burden.

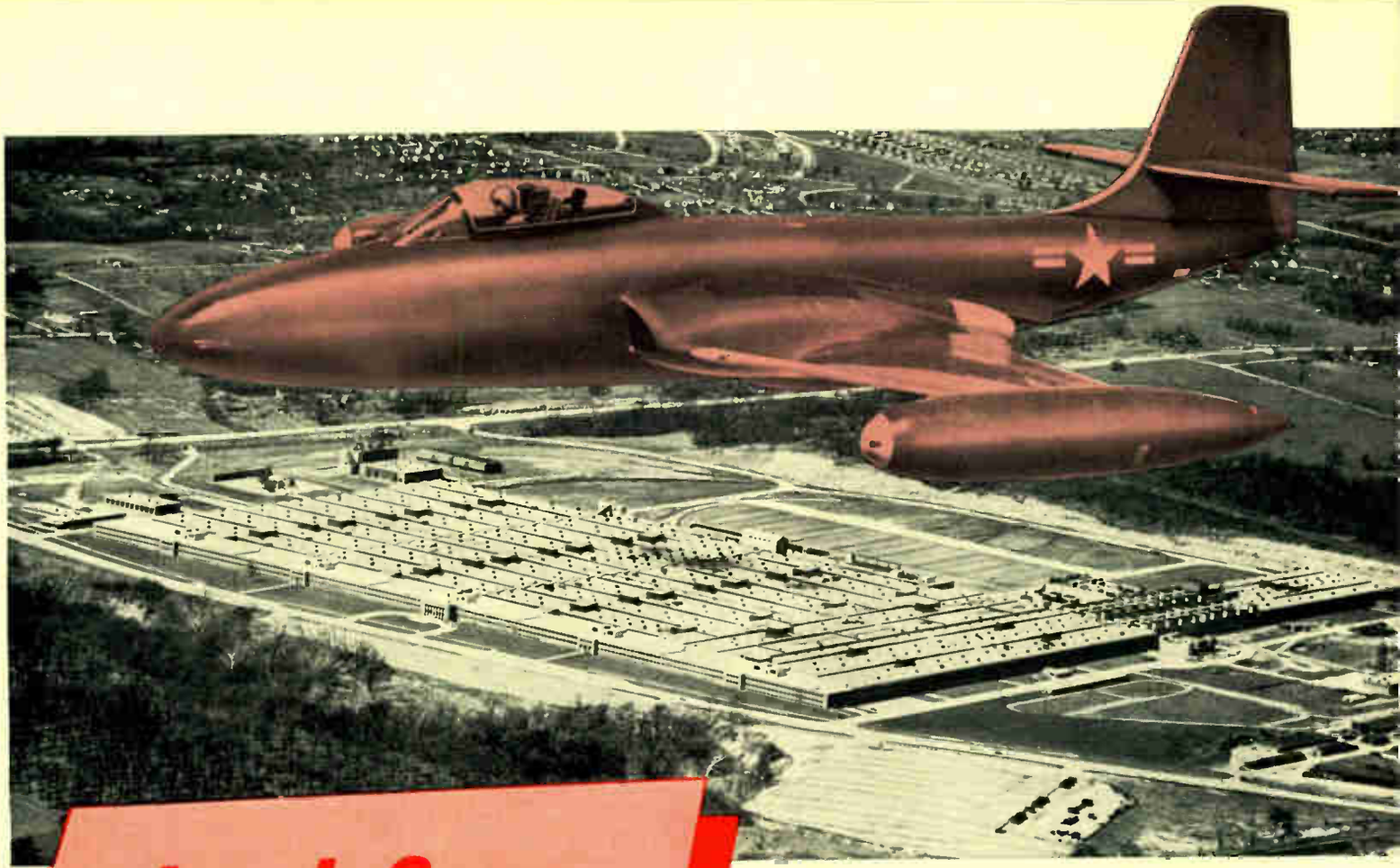
A synchronous condenser serves a wind-tunnel load. It has a rating of only 4000 kva, but is connected to a large a-c system. The reactive kva through a tie line is held constant, in spite of system load swings, by an electronic rkva regulator controlling this small machine.

A Continuously Variable Source of Megacycles

FOR A U. S. Navy application, a novel high-frequency generator has been produced. When provided with an external, standard, 100-kc frequency source, the equipment will furnish up to five watts of driving power at any—literally—desired frequency between one and seven megacycles. The accuracy and stability of the equipment is equal to that of the primary source. Furthermore, the frequency is shown down to the last cycle on a direct-reading instrument like mileage on an automobile odometer. The equipment employs a synthesizer-type frequency generator and has a built-in monitor for self-checking frequency accuracy. The unit is capable of providing both A-1 (on-off) emission and F (frequency-modulation) emission.

Power-Line Carrier Goes to Sea

TENDING a lighthouse is a lonely task. But tending a lightship bobbing around several miles at sea must be much worse. The U. S. Coast Guard has perhaps found the answer to that: make it unnecessary to man the lightship. Last fall it ran tests on an experimental lightship that can be towed out to sea, the anchor dropped, and left. Except for occasional inspection trips it is expected that the lightship will go through its cycle of duties without benefit of crew. Its three diesel-electric power plants, pumps, beacon, and other apparatus are operated by radio-transmitted signals produced by supervisory-control equipment of the type used for years by power companies to control unattended substations.



A McDonnell twin-engine jet fighter, the Banshee, is superimposed over the large plant near Kansas City devoted exclusively to production of aviation gas turbines.

Land, Sea, and Air

New Prospects for Rail Electrification

THE IDEAL power for a locomotive is electricity. Little argument is offered to that. From a performance standpoint, no type of self-propelled locomotive—steam, turbine, diesel-electric—can touch an electric locomotive drawing its energy through an overhead line from a central power system. But, electrification systems are expensive in first cost—and the entire investment must be made all at one time.

Under construction is a new type of locomotive that may go a long way toward lowering the cost of electrification sufficiently to widen its economic field. This is the ignitron-rectifier locomotive, of which two 6000-hp freight units are being constructed for the Pennsylvania Railroad.

Designers of railroad electrification have always been faced with two contradictory desires. They wish to supply the locomotive with a-c power at commercial frequency and voltage. But they would like to drive the locomotive with d-c motors, which have excellent speed characteristics, are more efficient, and require comparatively less maintenance. This dilemma has resisted solution. Meanwhile several other systems, quite successful from an operation point of view, have been employed. These include d-c power supply, a-c power supply, and d-c motors with motor-generator sets effecting the conversion, a-c low-frequency power supply, but using the single-phase commutator motor, that is now highly perfected.

The rectifier locomotive offers bright prospect of providing a true solution to the dilemma. The idea is not new. In fact Westinghouse experimented with it in 1913, but the rectifiers of that day were inadequate for the task. The ignitron rectifier, brought to a high peak of dependability during the war, appears suitable. Strong evidence of this are the results of trials with it as a power supply on a multiple-unit railroad car by the Pennsylvania Railroad in 1949.

Use of the mercury-arc rectifier to effect union of the a-c power supply with d-c motors does several things. The rectifier itself is physically small, light in weight, and has no moving parts. It makes applicable the well-developed, standard d-c motor built in quantities for diesel-electric locomotives. Also it would make possible the use of 60-cycle power transmitted to the locomotive at commercial voltages. This makes unnecessary the conversion equipment to change central-station frequency to 25 cycles and less expensive voltage step-down stations along the line.

Much attention of railroad men everywhere will be focused on these two revolutionary locomotives when they go into service, which is expected next year.

By using light-weight cars, such as these in Chicago, rapid-transit systems are reducing the investment per passenger. At right is a 4000-hp gas-turbine locomotive.

The rail car equipped experimentally with ignitron rectifiers to determine the basic soundness of this idea for rail service continues in service, although the tests are concluded. The experience with this rail car has been so satisfactory that it seems feasible for general rail-car application.

New Era for Railroad Radio

IN THE development of a particular class of apparatus the establishment of industry-wide standards for its use is akin to the 21st birthday in the life of a man. It signifies both that a certain stage of development has been reached and that enlarged opportunities and obligations are at hand. This has happened to railroad radio.

After some 25 years of experimenting with radio by individual roads the American Railroads Association has crystallized a set of standards for railroad radio. This has allowed manufacturers to create new designs incorporating all modern circuitry know-how, to employ manufacturing methods suited for quantity production, and gives assurance that the designs meet the proved railroad needs. These standards are purposely made stiff. With the growing demand for channels, frequency control is very important; a high degree of selectivity is clearly essential if radio is to be used on trains with FCC allotments of adjacent channels.

Last year Westinghouse engineers produced a basic system of railroad radio (type FE) to meet these standards in all particulars, both electrically and mechanically. To ensure that the equipment stay within its own frequency "backyard" a circuit was developed to hold the swing of the frequency-modulated wave within the limits of 15 kilocycles. This is achieved by circuits responsive to the product of signal (voice) amplitude and signal frequency. Frequency is controlled by crystals maintained at a constant temperature to ensure stability. A high order of selectivity is built into the apparatus. It is designed for two-frequency operation (one for talking and one for listening) although conversion can be made to four-frequency operation in either transmitter or receiver. In railroad service, reliability and sturdiness are of paramount importance. To achieve these goals the new apparatus employs the Fosterite treatment for transformers developed during the war to moisture-proof radar units.

New High-Speed, High-Capacity Tankers

THREE king-size tankers are being completed by Philadelphia Tankers, Inc., for its Persian Gulf run. These contain every modern facility to permit hauling the most oil in a year's time at least cost. They are big—each trip bringing in slightly more than a quarter million barrels of oil. (The tankers built for war service carried approximately 140000 barrels.) The new tankers are fast—capable of 17 knots, as against 14½ for the wartime tanker.

Powering each super-tanker is an 18 000-shp geared turbine, the most power ever applied to a tanker. To achieve economy, steam of a temperature high even in land practice is used—1020 degrees F, which is the highest ever employed in a United States vessel. As a further step in achieving economy, the owners specified an "attached" ship's service generator, which is directly connected to the intermediate-speed gear element of the reduction gear. This makes it possible to obtain ship's service electrical power at the water rate of the main propulsion unit when the main unit is running at a speed equivalent to 53 cycles and above.

Another novel technical feature of the power plant is the unusual degree to which the package idea has been carried. With the steam condenser as the basic supporting member, the "package" includes the high- and low-pressure turbines, reduction gears, throttle valve, all oil piping, all elements of the lubricating-oil system, ship's service generator and air ejectors. Simplifies installation.

Dollars and Seconds Saved in Vertical Transportation

THREE YEARS ago Westinghouse produced a limited-budget electric stairway 32 inches wide by taking advantage of designs for limited lift and employing the quantity production

that such low cost was expected to produce. The idea was eminently successful as it is applicable for the great majority of public buildings that can utilize electric-stairway transportation to good advantage.

It was only natural that these same ideas should spread to larger stairways. Soon to reach the market is the 48-inch wide stairway, a companion to the 32-inch. Like its smaller brother, it is limited to lifts of 23 feet, again adequate for nine tenths of the locations. This means that parts can be made lighter (and less expensive). Interchangeability of parts is worked up to the hilt. The motor and drive mechanisms—again using a design made solely for electric stairways instead of a modified elevator drive—can be mounted within the stairway truss instead of requiring a separate housing suspended from the ceiling, a necessity that has always added to the installation costs and had appearance disadvantages.

The elevator designer has a tough assignment. If he decreases the time for running between floors, the stop becomes less accurate and less smooth. If he attempts to improve the stopping qualities, he finds the time between start and stop increasing. He has, however, recently made considerable headway toward achieving both—fast runs from floor to floor and excellent stopping performance. This achievement is an improvement in the basic Rototrol control system. In this, the control is arranged so that a pre-selected car-speed pattern is tied in with actual car position at several points as the car approaches a floor level, and a more forceful speed-regulating system holds the car speed of this pattern. Thus the pre-selected speed pattern is accurately established when the car is 20 inches, 10 inches, and 2½ inches from floor level and the Rototrol system forces the car speed to follow this pattern in a rapid but smooth and accurate slowdown. About one inch from the floor level the car reaches a low landing speed of seven or eight fpm, so that as power is cut off, and the brake smoothly applied at ½ inch from floor, the car coasts to a soft accurate stop at floor level. Thus the car seems to glide in for a landing, which led to the name of the new system: Synchro-Glide. With this system the accurate control of the car speed relative to car position during slowdown permits an appreciably higher average rate of deceleration and in turn a higher average speed from start to stop. Although a higher maximum speed is attained on short runs, the major gain is the reduced time required for starting and stopping.

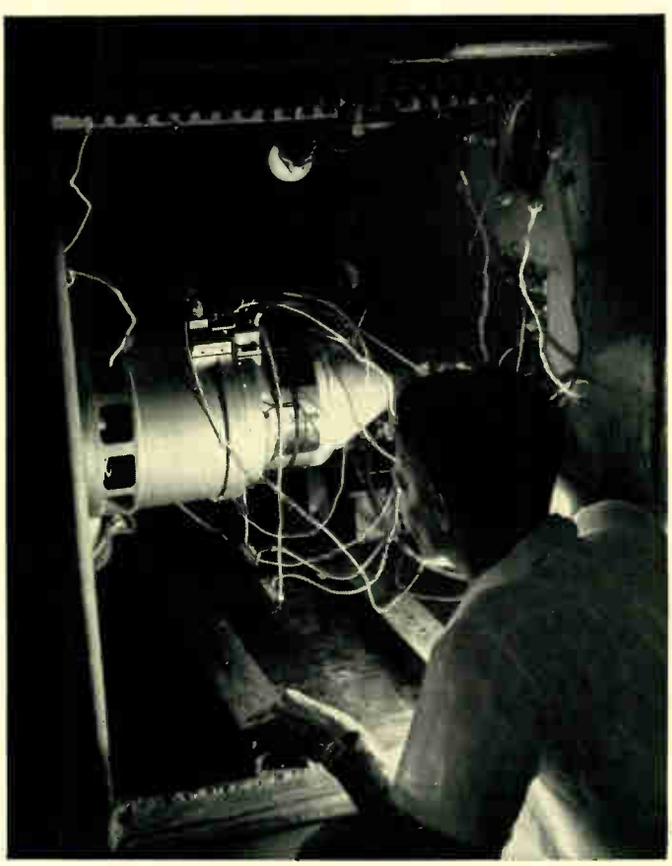
Electrical Apparatus for Aircraft

THE AIRCRAFT industry continues to provide problems of endless number and variety for the electrical-equipment builder. A few selected ones will give some idea of their scope.

Generators—The requirements for generators remain as always: more kilowatts from less weight and occupied volume, with the additional problems of operation through wider speed ranges and at higher altitudes. The famous P-1, 200-ampere, 28-volt, d-c generator of World War II became obsolete with the change to high-speed drives. Operation at 6000 rpm is common on reciprocating engines and operation at 7000 to 8000 rpm is common on jet engines. Since World War II the 30 000-foot ceiling of the P-1 generator is wholly inadequate, and operation at 50 000 feet has been achieved; 60 000-foot requirements are at hand. Extensive mechanical improvements make modern generators suitable for the high-frequency, high-amplitude vibrations encountered on today's large engines. Most planes now use 300-ampere generators, but requirements for 400-ampere generators are increasing rapidly. The 200-ampere generator is used on smaller airplanes, or where direct current is used for auxiliary power with a basic a-c power system.

A-c systems are well established and in use on several models of military planes. These systems require two types of alternators, one is for variable-speed operation and the other for constant speed; constant, that is, between plus or minus ten percent of rated synchronous speed. Of the constant-speed alternators the 60-kva unit is representative. It weighs 115 pounds and must carry full load up to altitudes of 60 000 feet where the air density is only about one tenth that at sea level—making cooling difficult. Alternators of 20 and 30 kva are also standard.

For loads where varying frequency is unimportant, alternators are gear-connected directly to the engine. These services include power for window heating, wing de-icing, cooking, and electronic loads. A typical alternator delivers 30 kva over a speed range of 4000 to 8000 rpm. An integral exciter matched to the carbon-pile voltage regulator maintains stable voltage



Left—A new a-c generator for aircraft on test. Below—A 25-hp motor for starting large aviation turbines.

control within ±2½ percent of rated voltage through the complete range of speeds, loads, and temperature ambients.

Motors—Motor loads are increasing, and tooling for the next larger motor size is justified. Now, a motor having a frame 5¼ inches in diameter has been standardized. It is being built for a variety of ratings, but at 10 000 rpm and forced cooled it can develop 5 hp continuously or 7½ hp on intermittent duty. Yet it weighs but 32 pounds, including radio-interference filter. These larger motors are used to drive fans, hydraulic pumps, refuel-in-flight pumps, and cargo-handling machinery within the plane. They are made explosion proof by inserting in each air entrance a cartridge consisting of a mesh of aluminum wool held between aluminum screens. Should an explosion occur within the motor the gases expelled through the cartridge are safely cooled.

Control—Acceptance of the centralized control panel for aircraft electric systems became general only last year, although the idea of consolidating the several widely scattered relays was first developed in 1946 and 1947. As airplanes grew the needs of their electrical systems also grew. A new protective device or relay would be developed, and, logically enough, the airframe builder would put the new addition where it was most convenient or where he could find room for it. This came to mean many widely scattered units, much interconnecting wiring, which is that much more chance for trouble.

This situation is corrected now with a central relay panel on which are mounted the overvoltage, generator-field, differential, voltage, equalizer, and ground-fault protective relays. The weight is only 12 pounds, somewhat less than for individually mounted units. Many feet of wiring is saved. Also, with centralized mounting, susceptibility to damage is enormously reduced. Isolation against vibration is possible with one fairly sizable mass, which is difficult with small, separated elements. A great saving in terminals and connectors also results, with some weight reduction.

When planes were small the pilot supplied the force through cables to adjust the wing flaps to his needs and checked the results by looking. Planes became too big for that. Power-operated devices took over, some with electronic controls to superintend the job. These devices work, but their operation is dependent on elements that lack the dependability essential to so critical a control function. The possibility of some element failure must be reduced to the absolute minimum. To avoid tubes, a new device without them and with no moving parts has been assigned this task. It employs eight tiny magnetic amplifiers, hermetically sealed in two metal cans, each smaller in volume than a teacup. With this system the pilot simply sets the wing-flap handle to the desired position and goes about other business. The magnetic-amplifier circuit, thereby unbalanced, forces the flap drive to move until current balance is re-established, whereupon the amplifiers cause the drive to stop. Flap position is thus brought automatically to the desired position with a maximum error of a fraction of a degree. Allows greater freedom to the pilot.

A Story of Jet-Engine Progress

NOTHING MAKES an engineering reporter more unhappy than to have a good story and not be permitted to tell it. Such is the position we find ourselves in each year-end as we sit down to report jet-engine development. Security regulations confine the story to generalities.

The essence of what can be said is this: by comparison with a year ago, Uncle Sam, for whom Westinghouse builds all of its jet engines, is obtaining jet power plants that provide more thrust from less fuel and for fewer dollars. Of particular significance is the performance of the J-34 engine which has permitted the recent increase in the interval between routine overhauls by as much as 100 percent. Incidentally, the average time between overhauls of this engine is longer than the comparable average achieved with the largest aviation piston engines when subjected to similar service operation.

Last year also became one of increased jet-engine production. Two years ago a large war-built piston-engine plant near Kansas City had been acquired by Westinghouse for jet-engine manufacture, and by the end of 1950 its output had reached a high level. With the sudden turn of world events in mid-year this additional source of jet engines proved most timely. Among other things it permits the original plant at South Philadelphia to become primarily an engineering, development, and pilot-production plant.

Three specific technical accomplishments can be mentioned as contributing to the continued improvement in jet-engine performance. One is afterburning. The principle of afterburning—burning additional fuel in the turbine exhaust to get a brief energy burst (at a sacrifice in fuel consumption)—has long been known. But it has been difficult to accomplish. The problem is how to protect materials that melt at 2500 degrees F from exhaust gases hotter than 3000 degrees F.

Afterburning has been made successful by providing a thin layer of relatively cool gas over the surface of the afterburner section. This is a tricky operation. Too much raw air would greatly reduce the thrust. Too little would result in engine failure. Afterburners use up all the remaining air in the gas passing through the engine. The mechanism for supplying just enough fuel is also tricky.

In any jet engine two variables bear on the all-important matter of fuel economy—engine speed and combustion-gas temperature. The pilot is simply unable—even if he had time—to work out for each thrust condition the most favorable combination of these variables.

Enter the electronic "brain!" Externally it looks no more exciting than a black box of a size that might contain a portable typewriter. Into this black box are fed four signals. One is a feeble signal from a thermocouple measuring turbine-exhaust temperature. A second signal representing engine speed joins this signal, as well as two "scheduling" signals from the pilot's throttle. The electronic circuit amplifies these signals and evaluates them. If the combination of variables is not the best for least fuel consumption for the thrust called for by the pilot, the control directs the proper corrections to be made. The pilot does not concern himself with this problem. He adjusts a single lever to obtain the desired thrust—i.e., flight speed. The "black box" does the rest.

Another development that is bringing down the specific weight of engines is use of a new metal—titanium. In ability to handle stress at elevated temperatures titanium is intermediate between aluminum and steel. The comparative weights for aluminum, titanium, and steel are about 3, 5, and 9 respectively. This has led to its use first for simpler elements and now, as welding and forming techniques are being developed for this new material, titanium is being applied for parts having more complex shapes and where temperatures are higher. The saving at each step is one of weight.

A few years ago titanium (dioxide) was principally an ingredient for paint. Now there is promise that the metal will become an important structural material. The commercial production of titanium, its processing, heat treating, forging, and now welding and shaping is an important story in itself.

Illumination, X-ray, and Home Appliances

A—A new airport-runway marker light using a single lamp in a special glass housing to give the desired vertical and runway pattern. *B*—A combination mercury-fluorescent lamp. *C*—A new dishwasher combines top loading without a top-opening lid. *D*—The electronic image amplifier gives the doctor a fluoroscope picture 100 times brighter.

New Directions for Mercury Lamps

A MERCURY-VAPOR light source has several powerful advantages. Among these are high efficiency, concentration, and a rich output of ultraviolet. It also has some inherent weaknesses, such as a marked deficiency in part of the visible spectrum, and inability to restart immediately after shutdown. The advantages are so attractive that great technical ingenuity is being displayed in overcoming the disadvantages. Several new examples of that are at hand.

Motion-picture producers like mercury lamps because their light source is small; they can deliver a powerful beam; and because, by comparison with carbon arcs, they require no attendance, no frequent changing of carbons, and are noiseless. To meet movie-studio requirements for better color quality, cadmium, which generates strong red lines, has been introduced into the mercury, as mentioned here two years ago. Recently the requirement for instant starting was solved by enclosing the lamp in a cylindrical furnace consisting of two halves hinged. When the lamp is not needed the two halves are closed around the lamp, and 850-watt heaters in each section maintain the lamp at an operating temperature ready for instantaneous starting.

The concentration of the light source has been further increased by use of the short-arc principle. New lamps developed for high-power searchlights are of 6 kw and 10 kw. This is a construction with heavy, closely spaced, special electrodes

The 10-kw and the 800-watt short-arc mercury lamps.

←
For movie studios, heaters around mercury lamps when they are not in use ensure readiness for operation without change in light quality.

With the new milk cooler the dairy farmer lifts heavy cans only a few inches instead of into a waist-high top-opening milk-cabinet. It cools the cans of milk with mild sprays of recirculated chilled water.
→

that result in a short, fat arc. Because of its greater energy concentration the arc produces a light of better quality.

A smaller version, the 800-watt short-arc mercury-vapor lamp, has been produced and has already found a wide variety of uses. At airports it is used to project a powerful, narrow beam of light vertically to the cloud layer overhead, whose height can then be determined by triangulation. This 800-watt lamp, which is self-cooled, does a somewhat better job with its concentrated arc than its predecessor, a 900-watt mercury-vapor lamp that demanded a blast of cooling air.

The same lamp has been found useful by the Corning Glass Works as an excellent source of ultraviolet light for the exposure of their novel photosensitive glass. The spectrum of this lamp is such that it gives about five times better efficiency than the carbon arcs previously used and without their maintenance requirements.

Many television programs are retransmitted motion pictures. The 800-watt short-arc lamp is superior in photoelectric effectiveness to the previously used incandescent lamp and is expected to have an average life about 50 times better than the 10 hours of most incandescent lamps now commonly used for this purpose.

Another solution to this same problem of televising motion pictures, and one that at the same time eliminates the projector shutter, is a vapor lamp that flashes 60 times per second in synchronism with blanking intervals in the television signal. The lamp is off during time of picture scanning and the film is moved from one frame to the next during the period the lamp is dark.

Another interesting solution to the color-quality deficiency of the mercury discharge is the wedding of the high-intensity mercury-vapor and fluorescent principles into a single lamp. The lamp itself is essentially the present standard 400-watt quartz mercury-vapor unit. The center section of the outer bulb has been given an oval shape to allow a uniform temperature, since the phosphors are coated on the inner walls of this section. The mercury-vapor produces its usual high-efficiency light. The phosphors—which are the high-temperature phosphors recently developed by the Lamp Research Department—convert the ultraviolet radiation previously absorbed by the glass into the red. The combined spectrum closely approaches white light and at no sacrifice in the total lumens-per-watt efficiency.

Mercury-vapor lamps have for a half century been used as a source of ultraviolet for photoprinting machines, particularly blueprinting—and now for white printing of engineering tracings. Last year two vastly improved mercury-vapor lamps appeared for such service. The problem has been to provide the desired ultraviolet lines and to eliminate the others. If the lamp is contained in the glass ordinarily employed for mercury-vapor lamps the efficiency in the desired region is relatively low. If quartz is used the transmission of the desired bands is good but ozone-creating radiation is also admitted, which requires a forced ventilating system for protection of personnel. This dilemma has been solved by the use of a new type of Corning glass called Vycor (7911), which has excellent transmission qualities of the desired radiation, but which blocks the ozone creators.

Two lamps using this new envelope material have been developed in cooperation with the Charles Bruning Company. One is a 3-kw lamp for its standard white-printing machine and the other is a 940-watt lamp particularly for a new, small, desk-size unit recently introduced by this firm. In addition to a superior envelope material the lamps employ a new, unactivated electrode construction using thorium. The thorium electrode brings several important advantages to these reproduction-machine applications. The lamps require about one third less warm-up time; they have longer life; and the life is unaffected by starts and stops so that machines can be shut down—as during noon hours—when not in operation.

Incandescents Improve

EVEN AFTER two thirds of a century of intensive filament-lamp development, improvements continue to appear by virtue of research and engineering-design efforts.

The sealed-beam lamp principle has been extended to lamps for bicycles. What, you say, is so remarkable about that? Sealed-beam lamps we've had for years. This is but an obvious extension of the automobile-lamp idea to the lowly bicycle. 'Tis even so, in principle. But the doing of it was something else. The filament for a 0.6-ampere, 3.7-volt bicycle lamp is of very fine wire. On the other hand, the Pyrex glass in which it is sealed is very thick. This means that the annealing time for the glass is long. If the fine-wire filament were allowed to oxidize during this long annealing time the resulting oxidized layer would be an intolerable proportion of the total filament diameter. Successful construction, therefore, demanded new manufacturing techniques, including use of a blanket of inert nitrogen atmosphere.

Another side street now traveled by the sealed-beam lamp is for hand lanterns. Here the precision, light-concentrating ability, and permanence of the sealed-beam lamp really pays off. By comparison with the conventional type, in which a bulb is used in a separate metal reflector, the beam candlepower is raised from 2700 to 5600—from the same battery.

A new reflector lamp idea has reached to the "photoflood" class of importance to photographers. A lamp only 3¾ inches in diameter consumes 300 watts to give compact but powerful

The 8-ton, 3-cylinder air-conditioning compressor is only two thirds as large as before. A compartment-type water cooler is an office convenience.

beam light source, particularly useful for taking home movies.

The carbon arc has been without peer as a source of intense, concentrated light. But it requires almost constant attention, which is becoming a greater and greater disadvantage. Incandescent-lamp engineers are making considerable headway in providing a lamp that needs no operator attendance and that matches, for some applications, the carbon-arc in light performance. Given this problem last year, engineers turned to an old lamp used for years at airports. It is a 3-kw, 32-volt lamp. The low voltage makes possible an exceedingly rugged filament of heavy tungsten. But the filament area was too large. It consisted of four parallel coils in a single plane. The apparent area was greatly reduced a third by placing the four filaments in two rows, one behind the other and staggered.

The resulting lamp appears to have extensive use where long throws of greatly concentrated light are required, as in motion-picture studios and large sports arenas. A novel use being considered in television studios is to project still or motion pictures on translucent screens behind the actors, thus providing the scenery suited to the performance.

Another long-troublesome lamp detail bit the dust last year. The large-wattage incandescent, infrared or oven lamps, and some of the mercury's, operate so hot that the cements ordinarily used soon disintegrate. This has necessitated various mechanical clamping devices — expensive and cumbersome —that sometimes break the glass bulb when applied. Also the area of contact between mechanical clamping devices and glass is small at best.

The silicone cements were known to have much better temperature resistance. But, whereas the ordinary cements cure or set in a minute or two, the silicone cements require many minutes to set—far too long for the pace of high-volume lamp machines. Someone suggested, use both! And the idea works fine, probably to the eventual elimination of all mechanical bases. The trick is to apply the regular cement in two opposite small areas and use the silicone cement on the remainder. The ordinary cement hardens fast and is adequate to hold the base and lamp rigid until the slow-setting silicone cement takes over, perhaps even continuing to harden and improve its tenacity in the heat of service.

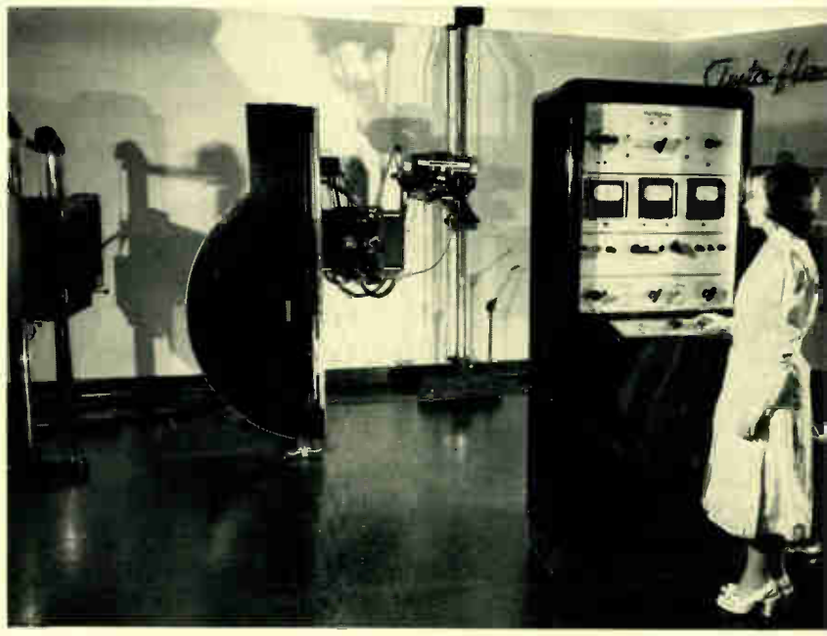
Simpler Airport-Runway Lights

THE TWO ROWS of pin-point lights that outline an airport runway present a considerable problem to the illumination engineer. Of the light available from the lamp most—but not all—must be compacted into two narrow wedges parallel to the runway. Some, however, must be reserved for projection above and to the side of the runway so that it can be seen by the pilot of any plane, from a Piper Cub to a B-36, making its normal circle above the field. Heretofore, these two functions have been separated—one lamp in a double-end housing giving the runway-edge information, another in a lens housing on top providing the circling identification. This is an efficient, effective system. But it is not inexpensive.

A new type of high-intensity unit combines these functions in a single lamp and lens in a simple structure. A standard runway marker lamp is enclosed in a bell-like glass hood. It is the shape of this hood that is unique. In horizontal section it is round with two flattened areas on opposite sides. In these flattened areas are cast "bull's-eye" that give the sharply directional pattern to the beam. The remainder acts as a lens to direct light upward in all directions.

For runways not operated for instrument landings a medium-intensity marker light is ordinarily used. It consists of a yellow cone surmounted by a lamp in a circular bell housing. This has been simplified and made less costly this last year, with some improvement in performance. Previously the inner and outer lenses were separate. Now they have been combined into a single piece of glass. The cone is made slightly smaller and by improved design the need for bracing has been eliminated. Saves weight and cost.

The timing of pictures taken with almost all Westinghouse x-ray equipments is now done automatically with photoelectric devices similar to those first used for chest x-raying on miniature film.



Constant-Current Regulators Are Smaller

REGULATORS that maintain constant current on street-lighting circuits are now lighter and smaller because of Hipersil steel. Use of grain-oriented steel for the core has, in the case of the 25-kw, 2400-volt regulator, for example, reduced the oil requirement from 74 to 57 gallons and the weight from 1380 to 1080 pounds. The new wall-type bushings (developed for distribution transformers, see p. 10) make for further reduction in space required by the regulator on the crossarm. Although these regulators normally operate many years without adjustment, a handwheel is provided should finer voltage adjustment than the guaranteed one percent become necessary.

More Convenient, More Automatic Home Appliances

IN THE endless parade of new home labor-saving devices, the conspicuous features of recent months have been improvements that make them more convenient to use or more automatic—particularly the latter.

Electric dishwasher—Among the household chores in the drudgery class, dishwashing has been one of the last holdouts against engineering solution. Mechanical dishwashers have had a long history but only recently have they become popular. Probably because only recently have engineers found answers to some of the stubborn dishwasher problems. There have been two types, from the standpoint of loading: through a top-opening lid or through a door in front. Each has its merit. If through a top lid, the working surface of that area is lost—and what kitchen has enough table-top area? While the sidedoor dishwasher provides usable top space, it requires the housewife to stoop and reach into the unit when loading with dishes, and gives the designer a tough water-seal problem.

A new dishwasher, believe it or not, retains the advantages of both. The entire washing mechanism is on rollers that pulls out from under the stationary top surface like a drawer in a file cabinet. The dishes are then loaded in from the top, which is waist, not knee high. Also the tub is rectangular with rounded corners, which give most possible usable dish space. In fact the dishwasher is believed to hold more dishes than any previously marketed domestic unit.

The water in the new dishwasher is pumped out instead of flowing by gravity. Hence a single flexible-hose connection to the adjoining sink is adequate; an additional gooseneck trap and atmosphere vent is not necessary. Saves plumbing. The washer is completely automatic in both its washing and drying cycles. The drying air—warmed by a heater—emerges through semi-concealed vents; no lids pop up to allow drying air to escape.

Electric range—The cooking side of the meal task—the electric range—also shows new improvements. The gas-fired range has always held one big advantage over the electric range—the time required to heat. A new range element, however, comes up to full temperature in less time than it takes to draw a kettle of water. When the super-speed Corox range element is turned on, it is first connected to a 220-volt instead of a 110-volt circuit. As a result four times as much wattage is poured into the element for a few seconds; 5000 watts instead of 1250. When the preselected temperature is reached, the element automatically returns to normal voltage.

The new range is made more colorful, literally—in a useful way as well as in appearance. A single 36-inch fluorescent lamp extends the full length of the control panel along the back of the stove. With this as the light source, a translucent panel behind each heat-setting knob lights up in a color appropriate to the temperature selected, and which the house-

The new refrigerator defrosts itself in a few minutes, when it needs it, and only as long as it is necessary.

The food mixer and the combination table grill have both been substantially improved.

wife can judge instantly from the far side of the kitchen.

Clothes Washer and Dryer—In the laundry department the Laundromat automatic-cycle washer has been equipped with a clothes-weighing device built into the door. The housewife then sets the control that fills the tub with water adequate for that weight load. The saving in hot water and soap on less than full-size loads is appreciable. An additional improvement is the use of Micarta molded gears in the drive mechanism, which makes for quietness.

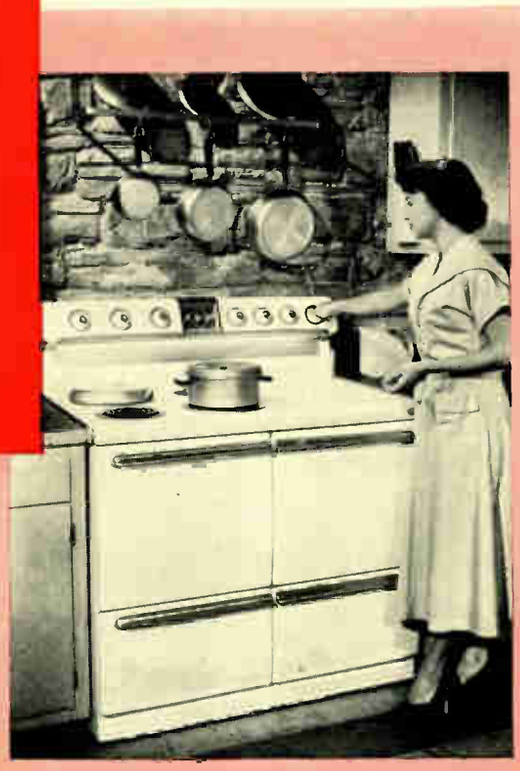
The 240-volt Electric Dryer, companion to the Laundromat washer, is now equipped with a double heater element instead of a single one that makes the clothes-drying operation independent of line voltage or incoming air temperature. One 3400-watt base-load element remains on throughout the drying cycle. A supplemental 1400-watt heater cycles on and off as needed to maintain correct drying temperature. Heat efficiency has been improved by a system that leads the warmed air into the tumbling clothes directly instead of seeping in through the holes in the basket. The lint trap now pops up at the end of the drying cycle to remind the housewife that it needs attention. Lint build-up is thus avoided. The dryer is completely automatic. The drying cycle stops when it should—i.e., when the clothes are dry (and the degree of dryness is adjustable) not after a fixed length of time.

For homes that do not have 230 volts, a 115-volt dryer has been made available. It, naturally, has a smaller heating element—1500 watts—and requires a drying cycle based on time because the exhaust temperature is too low to make automatic controls reliable.

Toaster—So simple an operation as making toast involves more than meets the eye. Most toasters take uniform brownness as the criterion of performance. Usually this is achieved by a control that doles out a fixed amount of heat. The time to toast is therefore variable. With this system, if the toaster starts cold and if the line voltage is low, the toasting time is long. The result—bread overly dried out inside. If, however, the toaster is hot and voltage is high, the time is short and a searing of the surface with little interior drying is achieved. Two pieces of toast, browned to the same degree, can be very different inside. To prevent this the new toaster operates on the basis of time as well as temperature. The thermostat is arranged to cycle the heating element on and off to produce a uniform amount of heat in a fixed time regardless of voltage or temperature at time of starting.

The new toaster has another feature that is widely appreciated. Small slices of bread, such as rye bread or English muffins, can be extricated from the toaster without burned fingers or using the tines of a fork. Pressing upwardly on a button in the handle lifts the undersize slices an additional inch. A small but much appreciated detail.

Sandwich Grill—Appliance engineers are using a well-known principle of physics to good advantage in the combination sandwich-pancake-waffle grill. It is that a black surface absorbs heat better than a bright, shiny one. This grill has interchangeable waffle grids and flat cooking surfaces of aluminum. To improve their heat-absorption qualities their backs have been treated with a baked-on black cement—one that withstands dishwashing. This change produced startling results. The heat efficiency is improved so much that although the amount of heat has been reduced from 1000 to 850 watts, waffles bake in 4½ minutes instead of 7, the temperature of the bottom of the grill next to the table is only 120 degrees instead of 180, and the terminal connections run at 450 degrees instead of 800. Much better heat distribution on both the flat cooking surfaces and the waffle elements is obtained.



The electric clothes dryer has a more efficient warm-air circulation system and a lint trap that cannot be ignored. The new electric range has a super-speed heating element that comes up to cooking temperature in only a few seconds.

New Improvements in X-rays

AUTOMATIC photoelectric timing of x-ray exposures by the Morgan-Hodges principle was applied by Westinghouse to miniature-film, chest-survey equipment seven years ago. This was the first commercial application and has worked so well that it has been applied to essentially all types of x-ray machines, including the large volume general-purpose variety. Under the old system the x-ray technician had to measure the thickness of that portion of the patient and select the appropriate kilovoltage, current, and exposure time with great care. Now the technician selects only the kilovoltage and current for the exposure. The phototimer does the remainder. It controls exposure time automatically to give pictures of correct and uniform density. The phototimer provides control in essentially infinitesimal steps, instead of a

few fixed steps as on previous timing controls.

The timer now being applied generally to x-ray equipments has been given several improvements. It is able to maintain correct film density over a wider range of applied voltages—i.e., for a wider range of radiation wavelength. The net effect of this is that the technician takes better pictures and gets greater detail. The timer is physically built into the apparatus instead of being provided as a separate adjunct.

General-purpose x-ray equipments in doctors' offices and hospitals require a vertical column extending from floor to ceiling and running on a track. The column gives support to the x-ray tubehead mounted on a movable arm and is precisely counter-balanced so it can be moved into any position and angle, and remains there. A new tubestand is a vast improvement over earlier ones in several respects. The tubehead can be elevated much closer to the ceiling than before—important because many doctors' offices are in low-ceiling rooms. The floor rail is stronger to prevent tube movement caused by "springiness" of the floor. A tubehead may have five or six locks that must be operated to obtain and hold the universal positioning of the x-ray tube. All those locks not within easy arm's reach of the technician's position are now electrically remote controlled. No more reaching across the patient or walking around the table to get at locks behind the tubestand. Appearance has been improved by "hanging" fewer devices and controls about the stand. They are made an integral part of it—yet servicing is simpler, such as the changing of the counter-balance should a tube of different weight be used.

When x-ray films have been exposed they must be looked at. This requires a viewlight, which is a frame containing lamps to illuminate a translucent glass screen on which the exposed film is laid for reading. It is about the size and shape of the usual bathroom medicine cabinet with a mirrored door. Last year designers really overhauled the previous design with two important results: the cost of the device is reduced by almost half. The performance is greatly improved in that the screen brightness is increased and is entirely uniform across the entire surface. Use of two fluorescent lamps and careful design of reflector provided better light utilization.

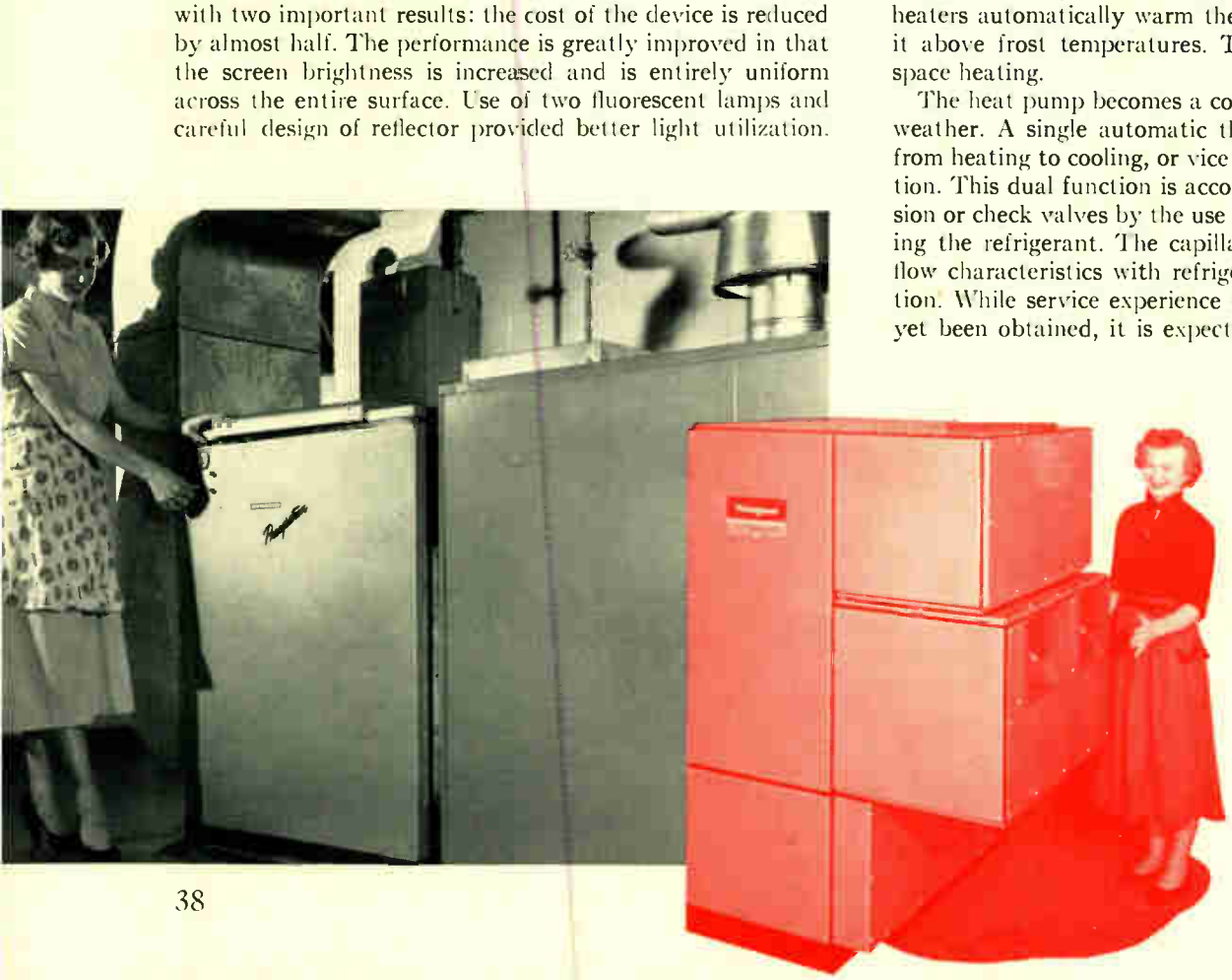
Film processing by Army doctors at the front is facilitated by a portable processing plant. It consists of a water refrigeration or heating system, master tank (into which the small separate process tanks are placed), and necessary flexible tubing. It can accept 100 degrees F water on a 125 degrees F day, and in four hours bring the temperature to 68 degrees F and hold it there. If the water is too cold it automatically warms it instead. The whole affair can be partially collapsed and carried by two men.

The industrial x-ray thickness gauge, such as is applicable to the measurement of continuous metal strip, has undergone further development and refinement. The original design, reported here two years ago, has been found to be sound but improvements have been added primarily to expedite changing the operation of the gauge as different thicknesses of metal are processed.

The Heat Pump Gets a Trial

THIS FUEL-LESS box (below) may be the furnace for mild-climate homes of the future. Also, in the summer it will reverse itself and provide cool air on hot days. It is an experimental air-to-air heat pump and air cooler. The system is a completely self-contained, packaged unit requiring only simple electrical connection and drain for condensed atmospheric moisture. When heating, air from the outside is circulated through a heat exchanger (evaporator) containing cold refrigerant liquid. This liquid absorbs heat from the warmer outside air, changes to a vapor in the process, and flows onto the compressor. The high-pressure, high-temperature vapor from the compressor flows to another heat exchanger (condenser), where the heat of compression plus the heat absorbed from the outside air are utilized to heat the home. When the outside air temperature is below 40 degrees F, electric strip heaters automatically warm the heat exchanger to maintain it above frost temperatures. This heat is also usable for space heating.

The heat pump becomes a cooling air conditioner in warm weather. A single automatic thermostat effects the change from heating to cooling, or vice versa, without human attention. This dual function is accomplished without any expansion or check valves by the use of capillary tubes for expanding the refrigerant. The capillary tubes maintain the same flow characteristics with refrigerant flowing in either direction. While service experience with this heat pump has not yet been obtained, it is expected that it can be used at 30 degrees F for extended periods and at temperatures as low as 20 degrees F for several hours.



Many of the new devices that do the work in the home cannot be identified by their shape. The young lady is standing beside the small metal cabinet that is the new Precipitron home air cleaner. The metal cabinet, in color, may be the future home furnace in winter and air cooler in summer. It is a new air-to-air heat pump.

A—Resonance radiation causes the light in the glass tube at the right, observed in a new fundamental study of gas discharges. *B*—Here are ionization gauges that permit measurement of vacuums as low as 5×10^{-11} mm of mercury. *C*—Strains in bones can be studied, using three-dimensional photoelastic methods and models made of a new plastic.

Materials and Research

New (and Old) Materials for Old (and New) Uses

MATERIALS ENGINEERS have been engaged in undercover activities. They are being pressed by designers to provide better ways of sealing electrical devices from harmful atmospheres and moisture—usually without adding weight, or at least not much. Some successes have been scored.

One technique can hardly be said to be new. In fact engineers perhaps took their cue from nature. Every natural-science museum and high-school science exhibit have specimens of insects trapped in nature's own resin—amber, the pitch of Asiatic pine trees—a half million years ago. The newest scientific copy of this is to cast whole electronic circuits in a synthetic resin. The circuit may consist of several miniature vacuum tubes, resistors, condensers, and all connections to plug-in type terminals permanently embedded in the resin. For show purposes the casting is done in sparkling, crystal-clear resin, but for normal practicality a filler of mica or silica makes the casting opaque and is mechanically superior. In any case the result is an electronic unit, moisture and shock resistant, light in weight, and small in volume. Many electronic units for aircraft gear are being cast in resin.

Another sealing method for electric devices employs the techniques common in the sentimental trade—the preservation of baby shoes. The methods, however, must be such as to obtain a better, less-porous plating. The method generally is first to coat the device to be sealed with an insulating plastic—such as Fosterite. This is then given a surface coat of a conducting material. Finally a thin layer of metal, copper or silver depending on requirements, is plated over the whole works. Obviously this adds almost nothing to the volume, little to the weight, and is applicable to irregular objects.

Still another sealing technique involves something new in plastic molding. A putty-like paste is made by mixing glass fibers in a polyester resin. This can then be injected cold and at low pressure into a mold, either to form a protective cover around a device or to form a useful article in itself, even for replacing certain expensive metal castings. The glass fiber contributes great strength and heat resistance. High dielectric strength and high moisture resistance are also obtained. One advantage to the process is that the mixture remains inactive until injected into hot molds whereupon it thermosets rapidly. The pressure required is only about one tenth that normally employed in injection molding.

A different family of molded products comes by using silicone instead of phenolic resins. Body is provided by mixing in fibers of glass or asbestos or mica dust. Molding is by conventional methods. The result is a product that combines extremely high heat resistance, impact strength, non-tracking characteristics, resistance to creepage, non-flammability, and excellent dielectric properties, both dry and wet.

Silicones are fast finding new uses in electric machinery. Transportation heavy-traction motors and generators built by Westinghouse employ silicone—along with companion high-temperature materials such as glass and mica. This has entailed the production of silicone in new forms. One is the production of a tape. Here silicone rubber is first milled, then applied by a calender to a glass cloth and oven-cured. This

tape has excellent chemical resistance, high thermal conductivity, retains physical, chemical, and dielectric properties from −70 degrees to 500 degrees F, a dielectric strength in excess of 500 volts per mil, outstanding heat resistance—material retaining flexibility and dielectric strength after exposure to 480 degrees F, and excellent dielectric properties and insulation resistance after immersion in salt water.

Two years ago the lightest of all substances, Insulfoam heat insulation was announced. This remarkable material, foamed and thermoset from synthetic compounds, has weights of 0.2 to 0.6 pound per cubic foot—(compared to about 8 pounds per cubic foot for balsa wood). Insulfoam insulation originally required the application of heat to complete the reaction. Last year the process was greatly improved by techniques that allow the foam to be produced at room temperature.

Photoelastic Resin

DIAGNOSING a disease after the patient has it is, of course, important. Of more value to the patient, however, are analyses of the causes of the disease, and preventive action to stop it before it starts. So it is with engineers in the case of fractures in materials, and the stresses and strains that cause them. By fracture tests they can determine a great deal about the reason for the break; by using photoelastic models of the part involved, they can determine where the regions of greatest stress and strain are located, and take steps to correct the weakness—even before the part itself has been made.

Photoelastic models of any machine part or structure—a crane hook, a nut and bolt, or most any other part—are first heated, then subjected to a stress, then cooled. This "freezes" the stress in the material. A concentration of colored (when viewed through polaroid lenses) bands indicate the locations of greatest stress.

Up to a little over a year ago, photoelastic models were largely two-dimensional. The particular plastics used could be made in plates of only about an inch in thickness. Then research men, Milton M. Leven and Herbert F. Minter, found a new plastic—a member of the Fosterite family of resins—that could be cast in chunks 10 to 20 times as large, and a new field for photoelastic studies was opened.

At that time the new resin was a brand new laboratory discovery; now it is in wide-scale practical use in industry and research. Typical of the applications found for this new resin are its use in the design of breechblocks for large guns, where a scale model can be constructed to study the tremendous stresses encountered when the gun is fired; its use by airplane-engine manufacturers; and by numerous college laboratories working on various projects. An interesting new possibility is its use in analyzing the stresses in human bone structure caused by heavy blows and fractures. This necessitates only the carving of the bone from Fosterite resin, and loading it.

The new Fosterite is about 35 percent more sensitive than standard photoelastic plastics, in that it forms more stress lines. Since analysis of the stress depends to a large degree on the ability to count the stress lines, a large number leads to more accurate results.

A Novelty Today; A Light Source Tomorrow?

IN A ROOM of the Westinghouse Lamp Research Laboratory one may be shown a small rectangular glass plate. Close a switch and the entire plate glows faintly with a pale, greenish light. It is a demonstration of the phenomenon of electroluminescence, known in principle since it was discovered in Germany about 1920. As a light source it is a novelty only, for the efficiency is insignificant—only about one third lumen per watt (incandescent lamps 15 to 20; fluorescent 50 to 60). But while interest in it is as yet academic, it does represent a new light-source principle, which some day may be important.

The device is a sandwich in which a layer of phosphors is placed between a plate of conducting glass and a metal layer. It resembles a condenser in which the phosphors are the dielectric. When an alternating electric field is applied the electrostatic strains—for some reason not clear—cause the phosphors to emit light.

Measuring "Nothing" Precisely

A PERFECT VACUUM is one of those goals that scientists continually strive for but will never attain. But as they come ever closer one question becomes increasingly important: just how close are we? The answer is not easy—the closer you come to "nothingness" the harder it is to measure. A new ion gauge—some 200 times more sensitive to pressures than any previous device—adds to the preciseness with which engineers can measure vacuums.

One day last spring, engineers in the Interatomics Physics Section of the Westinghouse Research Laboratories were performing one of the important tasks that are an integral part of their research programs. An immediate problem was that of filling several tubes with a very pure gas such as helium. To do this it is of course necessary to evacuate the tube as completely as possible. They got down to 10^{-8} mm of mercury, which many would say is as low as one could attain. But Dr. Daniel Alpert, head of the group, was convinced that the vacuum they were obtaining was even better than the device indicated, and that some inherent limitation in the conventional ion gauge prevented a reading below this value. So he assigned engineer Robert T. Bayard to investigate. After weeks of experimentation, it was discovered that the conventional ion gauge was no longer reading the gas pressure accurately but was indicating a current produced by very soft x-rays within the tube itself. With this information a new ionization gauge was developed that virtually eliminated the x-ray effect and made it possible to read pressure down to as low as 5×10^{-11} mm of mercury.

The ion gauge somewhat resembles a triode vacuum tube in structure. The ion collector is a fine wire, which runs up through the center of the tube. Surrounding it is the cylindrical grid. Outside the grid, on one side of the tube, are two filaments, one a spare. Electrons emitted by the filament are attracted toward the positive grid at high velocities. So great is their velocity that many speed by the grid, are attracted back, still at high speed, and may pass the grid several times. Some are immediately collected by the grid, but many strike atoms and create positive ions. Ions thus created inside the grid are attracted to the negative ion collector and provide a current indication in the wire proportional to the number of ionizations that have occurred. Since the mathematical probability of an electron striking an atom in its flight depends upon the density of the gas, which is in turn dependent upon pressure, the collector current is an indication of pressure. Ions that are created outside the grid either fall back upon the filament or on the glass envelope.

The tube is so simple and yet so rugged in construction, and fills such a vital need, that it went from its research stage to production preliminaries at the Westinghouse Lamp Division in about six weeks.

The Wellsprings of Progress

The examples of technical progress that fill the preceding 40 pages illustrate, among other things, a variety of incentives. Some are the materializations of new knowledge born of research. Others are possible because of new materials. A few come about because of the ingenuity of machine designers. And then some product improvements result from new manufacturing methods, or the installation of better production tools. All these and perhaps others lie within the boundaries and control of the manufacturer.

There is another large family of progress items, the incentives for which come from other organizations. Engineers of industrial companies under competitive pressure, trying to counter rising costs of man power and materials, and at the same time improve products, dream up the impossible and then ask equipment manufacturers to help accomplish them. Some are included in the preceding pages, but there are many more.

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Almost every producer of goods is attempting to increase machine output or provide more precise process control, or both. As an example, a manufacturer of synthetic fiber has a machine driven by a d-c motor. It was required that the speed at all loads and within a four-to-one range be held constant within 0.1 percent. Also tension in the fragile fibers must be held constant at all speeds. Further, a companion machine must run at a different but related speed, the relationship being held within plus or minus 0.1 percent under all conditions, including acceleration and deceleration.

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In preparing coiled sheet for tinning, a steel manufacturer desired to trim rough or damaged edges and hold the variation of the coil edge to within 1/32 inch. Also this was to be done at high speed—with the strip moving through the edge trimmer at the record speed of better than 3000 feet per minute. (A speed of 3600 fpm or 40 mph has been attained in test runs.) This has been accomplished by photoelectric edge regulators and suitable control of trimmer motors. The control has met the further requirement of maintaining the speed of the cutter at any preselected amount faster than the rate of travel of the strip for all strip speeds.

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The operator of a steel-annealing furnace asked that a 15-hp motor be shaft connected to a blower only 14 inches away that handles gases of 1500 degrees F. The bearing and motor, obviously must not be overly hot. A special shaft and a novel heat-conducting system gave the answer.

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A power company set out to improve and increase the accuracy of routine testing for its watthour meters. Its needs carried beyond the accuracies of existing so-called precision transformers. Also the test transformer had to be built for many transformation ratios—and physically could not be as "big as all outdoors."

The transformer designed for this need provides a full-load secondary current of five amperes within ± 0.03 percent on any of 14 primary taps for loads between 0.25 and 50 amperes. Conventional multi-tap transformer accuracy is 0.1 percent. The problem in maintaining such a high order of accuracy from a transformer with so many taps is to prevent interaction of the many windings under the wide variety of connections and loads. It was solved by a novel interlacing of windings on a biased-type core (in which one segment of the core carries more turns than the other). The core is of Hipersil grain-oriented steel—a weight-reducing factor. The complete high-precision transformer weighs but 35 pounds. The largest dimension is a foot.

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Someone else required an alternating current of exactly one cycle per second. Instead of providing it with an alternator operated in "slow motion"—say, a two-pole machine running at 60 rpm—it is done with three d-c generators. These machines are connected in wye, one for each phase. The fields of these generators are varied in a sinusoidal manner at one cycle per second and 120 degrees out of phase, to give balanced three-phase supply. The mechanism for providing the sinusoidal field is a small commutator, itself unusual in that the brushes move, the commutator is stationary. Six brushes spaced equally about the commutator and connected to three collector rings provide the excitation for the three d-c (or should we say a-c?) generators.

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With such never-ending incentives the prospect of any leveling off of technical accomplishment simply does not exist.

With improved ventilation, turbine generators can carry more load. A new blower, with two rows of differently shaped blades instead of one, provides one third more air for cooling at greater pressure.