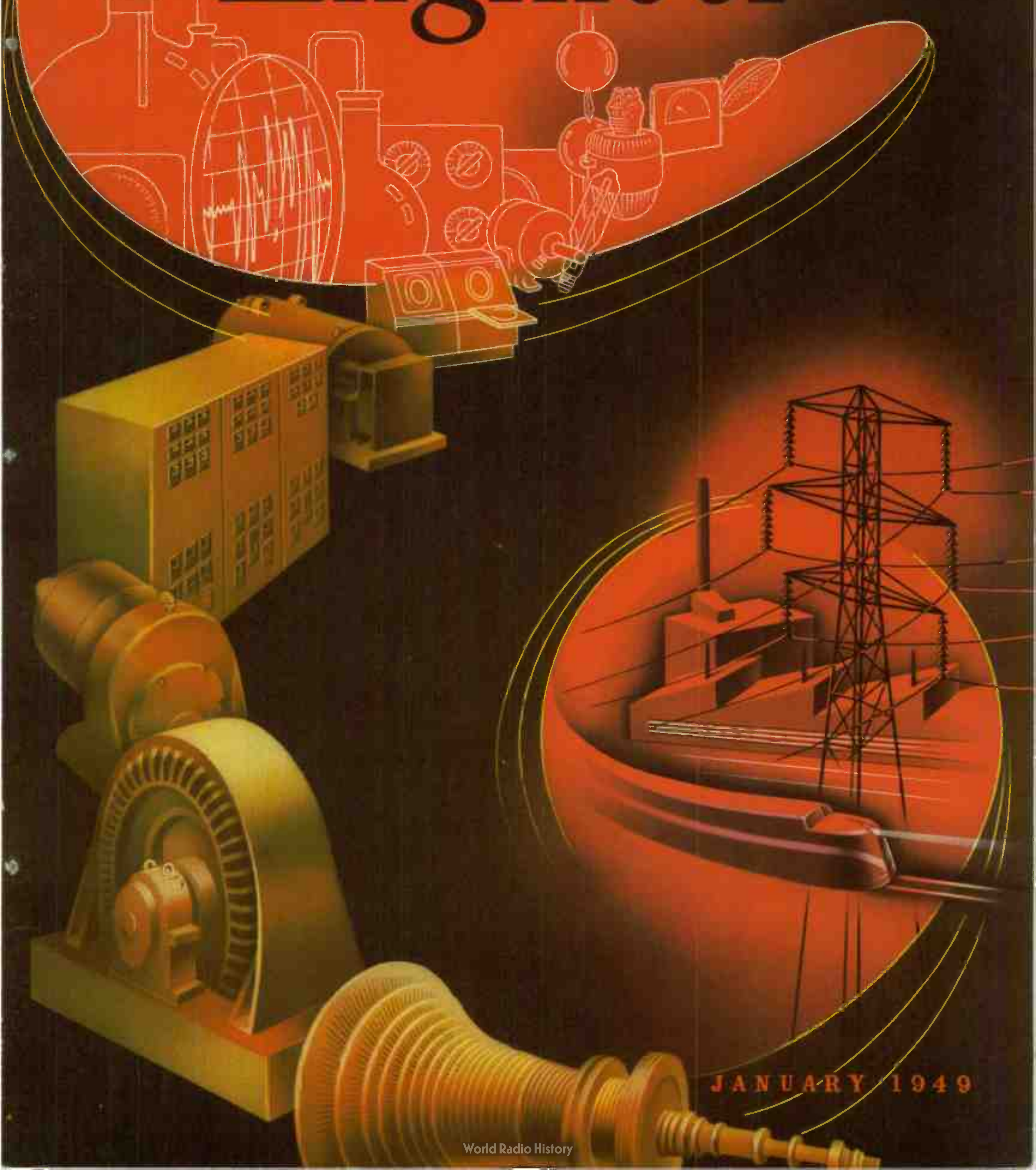
JAN 12 1949

WESTINGHOUSE Engineer



JANUARY 1949

World Radio History

Engineering Progress—By Inches and Miles

The dramatic and spectacular developments in the world of science and engineering make good reading. There's no denying that. An engineering review such as this could easily highlight the more glamorous items of the past year, and skip briefly over the less spectacular developments. We could talk about the new image amplifier, which promises to provide an x-ray image over 500 times as intense as the present image; about the big jump in transformer ratings from 100 000 to 145 000 kva; about the new radiation counter that will aid in medical studies and other radiation-detection applications; about the significant facts gained from further testing of the gas turbine for locomotive use; about the successes of Stratovision; or about the application of color television to medical studies. But engineering progress simply is not founded on the spectacular alone. In fact a half century from now the big events of today may very well have faded into insignificance beside the slow, steady progress of some device which this year may have crept forward only another inch toward eventual perfection. For engineering progress evolves from these inch-by-inch gains. True, some years provide two-inch gains, but engineering progress in a given year can still be measured with a small rule. The fact is that twelve months is but a tiny period in the span of engineering progress.

The biggest contributions to scientific progress simply do not evolve quickly. An engineering development is often based on work done by other scientists fifty or a hundred years previous. The incandescent lamp is an outstanding example. Edison, who is usually credited with the development of the lamp, actually did not discover its principle, nor did he build the first successful lamp. Davy, in 1802, demonstrated the fact that an electric current passing through a metal strip heated the metal, and that if it were sufficiently heated it would give off light. Many other people built successful lamps between Davy's time and Edison's first lamp in the 1870's. Edison did, however, make the lamp practical for widespread use, partly by employing principles and ideas of previous scientists and partly through ingenious solutions of his own. In the seventy years that followed Edison's lamp many scientists contributed to its further improvement—Just and Hanaman, Langmuir, Coolidge—to name a few. Over a hundred and forty years have elapsed since the principles of the incandescent lamp were demonstrated—yet in the year just gone, further significant improvements on the incandescent lamp have been registered. Engineering progress by inches!

Examples of this type of progress are not hard to find, whether the development is an atomic principle or a can opener. Trace the development of the electric locomotive, the steam turbine, the single-phase motor, or innumerable others and you will find the same situation—long years of research and development before the device is made practical, and then continued but gradual improvement and refinement. Steam turbines have a long and successful history in central-station service—over fifty years—but this period has been marked by continual improvements; this year showed an increase in temperatures from 1000 to 1050 degrees. The mercury-vapor lamp was developed by Cooper-Hewitt in 1901; but it has always been plagued by a deficiency of light in the red region of the spectrum. Now there is high prospect that that deficiency will be greatly reduced by the discovery and application of a new phosphor, which converts some of the radiations to the red region. The life of the standard mercury-vapor lamp has been boosted from 3000 to 4000 hours. Engineering progress by inches!

The steam locomotive has over a hundred years of successful operation behind it, during which time many refinements were made. Yet the ultimate in steam-driven transportation has not been reached. Plans have been made and engineers have worked preliminary designs for a new high-temperature, high-pressure boiler for steam-turbine locomotives. Consideration is now being given to actual construction of a test unit, which promises greater efficiency and performance. Engineering progress by inches!

The fact that engineering progress is relatively slow and that few spectacular developments occur does not in any fashion reduce the importance of the developments in short spans of time. Any twelve months finds the culmination of many years of work in finite and practical devices. And each period finds important discoveries of principles that lead to significant developments next year or the one following. Pieced together with the work of last year, next year, and the next ten, these discoveries and applications will make major contributions to the welfare of the world. The fact that engineering progress continues steadily on its way is in itself a healthy sign. For technological progress reflects not only an alert and vigorous group of scientists and engineers, but also a healthy and vigorous nation—no major nation can long survive without technological progress along many lines.

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On the Side

The Cover—The parade of commercial and industrial equipments perpetually passes by the reviewing stand of flasks, retorts, and oscilloscopes that represent research and development laboratories. These laboratories act as production and quality-control supervisors that are unceasingly making large and small changes to the benefit of equipments and their users. This cover design was conceived and executed by Cushing & Nevell, New York.

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After the story on the All-Weather Approach Lighting System (see *Lights That Penetrate Fog*, page 13) had gone to press, it was announced that seven sets of such equipments will be installed at Berlin airports (including Tempelhof Airdrome) to help the pilots engaged in "Operation Vittles." Each set contains a row of six lamps (three krypton and three neon) spaced 200 feet apart over a distance of 1000 feet. These six-light systems are intended primarily for field location.

• • •

Now available without charge are two indexes of material that has appeared in the *Westinghouse* ENGINEER. The first is a cumulative index of Volumes I to VII, 1941 to 1947. The second is an index of Volumes VII and VIII, 1947 and 1948. Bound copies of Volumes VII and VIII (together with index in a single book) are available at a cost of $6.00. If loose copies for Volumes VII and VIII are supplied by the reader, they will be bound (with index) at a cost of $3.50. Missing issues will be supplied at a cost of 35c each. Send requests for indexes, and 1947–1948 copies for binding, to the *Westinghouse* ENGINEER, 306 Fourth Avenue, Pittsburgh 30, Pa.

In This Issue—*Engineering Highlights of 1948*

Editor
CHARLES A. SCARLOTT

Editorial Advisers
R. C. BERGVALL
T. FORT

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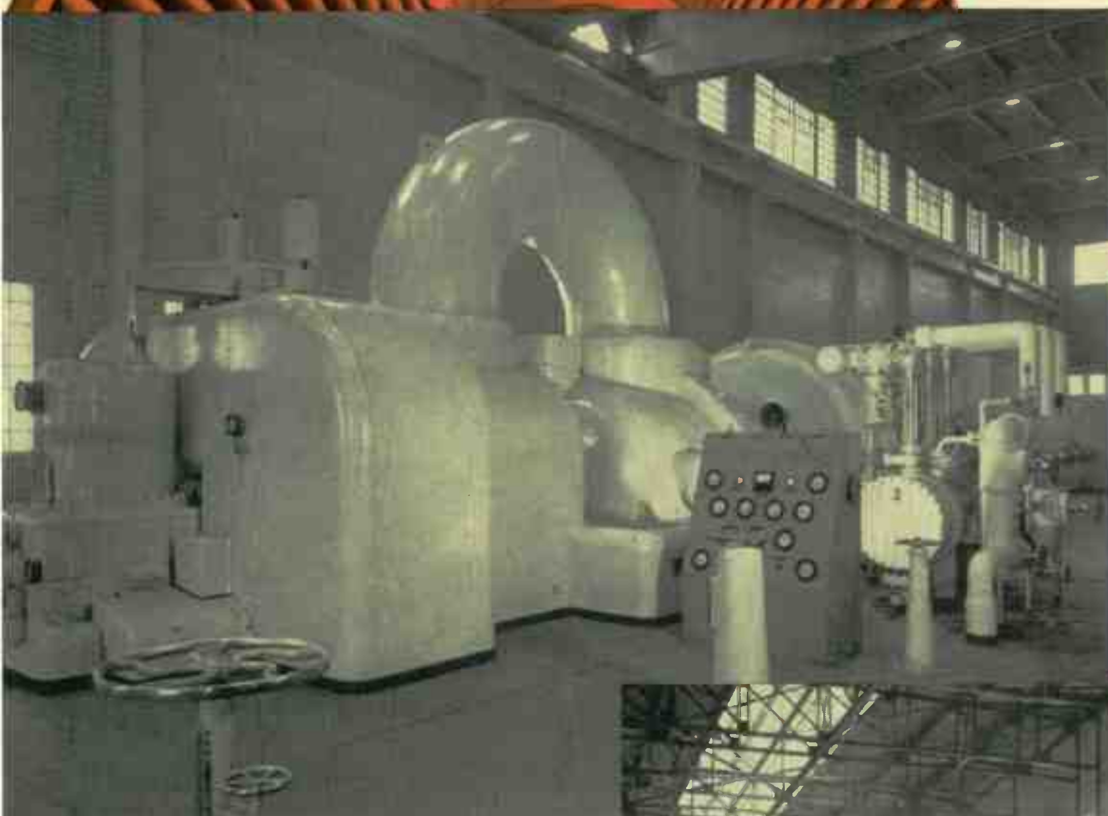
Generation of Power



This gleaming 60 000-kw unit becomes the fifth in a midwest power station. To meet rising loads, a sixth is being built.

Indicative that large 1800-rpm units remain in the central-station picture is this 107 000-kw machine in the Calumet station of the Commonwealth Edison Co. Since its initial operation late in 1947, it has achieved an extremely creditable load performance.

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The expected decline in demand for electric power when VJ-Day brought an end to war-swollen production did not materialize. Thus electric-power companies did not get the "breather" needed to replace war-tired apparatus. As a result they and electrical manufacturers were forced into a feverish program of construction far beyond anything known before. Now—three years after—the end is not in sight. A long-range survey of electric-power demands in this country shows that in the decade from 1947 to 1957 the electric-power companies will probably double their present investment in new plants. Kilowatthour sales are expected to increase by 72 percent in the ten-year period.

Indicative of the vigor with which this staggering program has been begun by manufacturers and power companies is the fact that Westinghouse built 1 300 000 kw of turbine generators in 1947, while for the year just closed the total was 2 000 000. Westinghouse's previous record was set just 20 years ago, in 1928, when 850 000 kw of turbine-driven apparatus was built. By major expansions of its turbine and generator plants, Westinghouse expects to be able, in 1950, to build 2½ million kw of new machines of various sizes. Of this, the entire capacity of the plant to produce large turbines in 1950—about 2 million—is already scheduled for specific machines. Definitely, no slump can be foreseen in the steadily rising curve of electric-power utilization.

A glance at the 1948 crop of electric-utility turbine generators discloses the continuance of some previously apparent trends and the appearance of some new ones. For example, the swing to standard units has become more complete. Of the turbine generators purchased in 1948 within the range of standard sizes (11 500 to 60 000 kw, 3600 rpm) more than 50 percent were of the standard variety.

The rise in top temperature—to 1050 degrees F—from a previous general level of 950 has been achieved with the operation of the 100 000-kw turbine generator in the Sewaren Station of the Public Service Electric and Gas Company of New Jersey. This temperature has necessitated the use of stainless steel throughout the turbine-inlet components. Also, this unit will operate at a pressure of 1500 pounds, considerably above the general level of 1250, but this is by no means a new record for turbine pressures.

The trend to higher temperatures is not limited to the largest machines. A 40 000-kw turbine for the City of Detroit is to operate at 1000 degrees.

The 80 000-kw, 0.8-power-factor unit at 0.5-pound hydrogen pressure, now in operation at the Buffalo Niagara Electric Corporation, marks the present top in the continued rise in size of single-shaft, high-speed (3600-rpm) machines.

Both the Buffalo and the Sewaren machines are the first to employ the new, longer 23-inch blade in the last row. This blade rotates with a tip velocity of 1380 feet per second—well above sonic velocity.

The rising cost of fuel has brought the return of steam reheating to popularity. After a virtual disappearance for two decades, five reheat machines are under construction. The history of steam reheat illustrates the fluidity of engineering ideas that continually seek economic balance. When turbine temperature rose to 750 degrees F in the late '20's, it appeared that a temperature ceiling had been reached. To obtain better economy, steam pressures were raised to 1250 psig, which required the use of reheat to reduce the moisture in the exhaust blading. Reheating was conducted at lower temperatures, consequently the reduction in heat consumption was small. Then the development of new materials permitted the next succession of temperature increases; they made higher Btu economy possible at lower cost than by the complexity of reheating. Now, with renewed pressure for more kilowatts per pound of coal, reheat is again finding favor. As a rough guide, a practical reheat cycle delivers about a 4½ percent increase in thermal efficiency—about the same as is secured with 150 degrees more temperature. The first of this new family of reheat machines will see service this year.

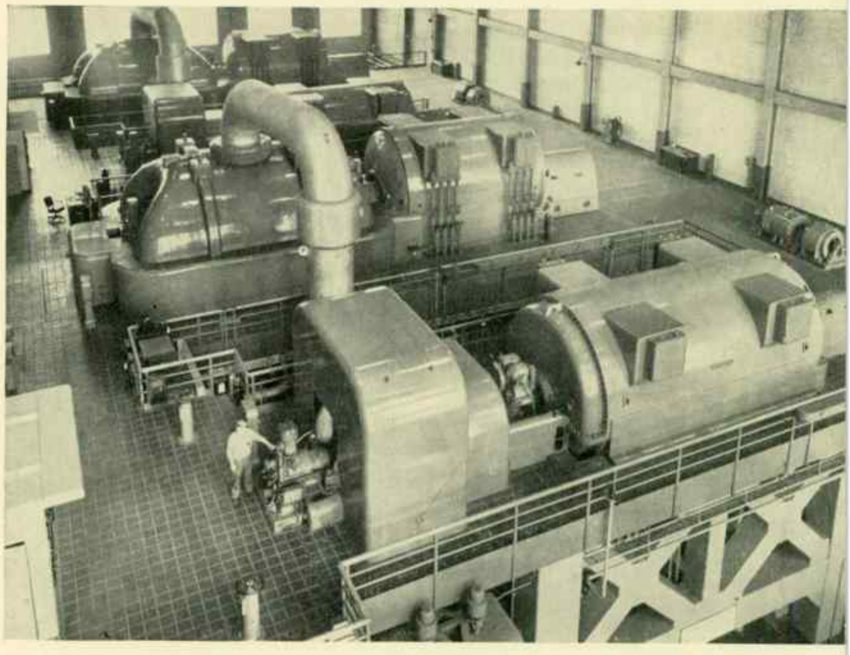
Among the machines unusual in their special features, three should be mentioned. One is a 30 000-kw turbine for installation by Dow Chemical Company. Not only is this an outsize machine for non-central-station service, but also it supplies process steam at three different pressures. Steam is extracted at two intermediate points under automatic control, the remaining steam being exhausted at low pressure. This has entailed an uncommonly complex control system. Two turbines—one of 6000 kw and one of 2000—operate as standby power for powerhouse auxiliaries. Normally idle and cold, they must be able to pick up full load within about 15 seconds.

One way of increasing the capacity of large two-pole generators with little or no construction changes is to increase the pressure of the hydrogen atmosphere. Already the swing from 0.5 pound to 15 pounds (gauge) is fairly prevalent among the larger machines. This doubling of the gas density increases the output available for the same temperature rise by 15 percent. Now a further increase to 30 pounds for machines of 65 000 kw or larger is being considered for the additional 10 percent capacity it provides (25 percent total capacity increase by comparison with 0.5-pound hydrogen). Two machines, in fact—the 100 000-kw unit of Public Service Electric and Gas Company of New Jersey and the 80 000-kw unit of Buffalo Niagara Electric Corporation—have been tested for operation at this higher pressure.

The boost in gas pressure from 15 to 30 pounds entails no changes in the cooling system. However, to meet safety and insurance requirements, a hydrostatic pressure test is necessary. The higher capacity gained in this manner is achieved at essentially no loss in efficiency. It does presume, of course, that the turbine is able to drive the generator at the new load.

As generators increase in rating the excitation requirements likewise increase. This has brought about a new step in exciter

The two machines in the foreground comprise a 150 000-kw generating unit in the Southwark station of the Philadelphia Electric Co.



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One of three steam-turbine, electric-drive locomotives in high-speed passenger service on the Chesapeake & Ohio Railway.

voltage. For years standard excitation potential has been 250 volts. The first machine with a direct-connected exciter for 375 volts is the 65 000-kw unit at the Springdale Station of the West Penn Power Company. This machine is under the control of a three-field Rototrol exciter, which eliminates the contact-making regulator.

Another excitation scheme in which the pilot exciter is eliminated altogether is being watched with great interest. It is a two-stage, main-generator Rototrol exciter in which the amplification is great and a pilot exciter is not needed. This Rototrol exciter supplies excitation, provides stability, and controls the voltage of the a-c generator with only one moving part, the Rototrol armature. The first of this type to see service is the 60 000-kw machine of the Southern California Edison Company at its Redondo Beach Plant, which went into service early in 1948.

Among other variations of excitation systems is one using a pilot exciter without brushes. This is a generator with a permanent-magnet rotating field. The a-c output is rectified by selenium or other rectifiers, so that no sliding contact surfaces are required. A 2-kw pilot exciter of this type is serving the 35 000-kw machine in the Seward Station of Pennsylvania Electric Company.

Gas and Steam Turbines for Railroads and Industry— Not just one or two but several new locomotive-drive developments are appearing on the railroad scene. Steam-turbine electrics made their first service appearance last year. Three are operating on lines of the Chesapeake and Ohio Railroad and have lived up to the performance expected of them.

The next step in the evolution of steam-turbine locomotives is an improvement in the boiler. A cooperative development by Babcock and Wilcox, Baldwin, and Westinghouse is to result in a 4500-hp locomotive with the boiler supplying steam at 600 pounds, 900 degrees instead of the 300 pounds, 750 degrees essentially standard now. Use of higher steam conditions and lower turbine back pressure, made possible by using forced draft, will result in considerably improved fuel economy and a much smaller boiler. Forced draft is expected to increase combustion efficiency materially. The turbines, electric drives, and controls will not differ radically from those used successfully on other turbine-electric locomotives.

The gas-turbine locomotive is expected to become a reality late this year or early next year. Now under construction are its two 2000-hp gas-turbine power plants. These will follow closely the general arrangement and construction of the 2000-hp unit, which has been plant-tested for two years with very successful results. The locomotive will have a total turbine rating of 4000 hp, will be only 78 feet long, and will have power applied to eight axles. For comparison, present diesel-electric locomotives of this power for passenger service employ two units of about 150 feet total length and have power applied to eight axles.

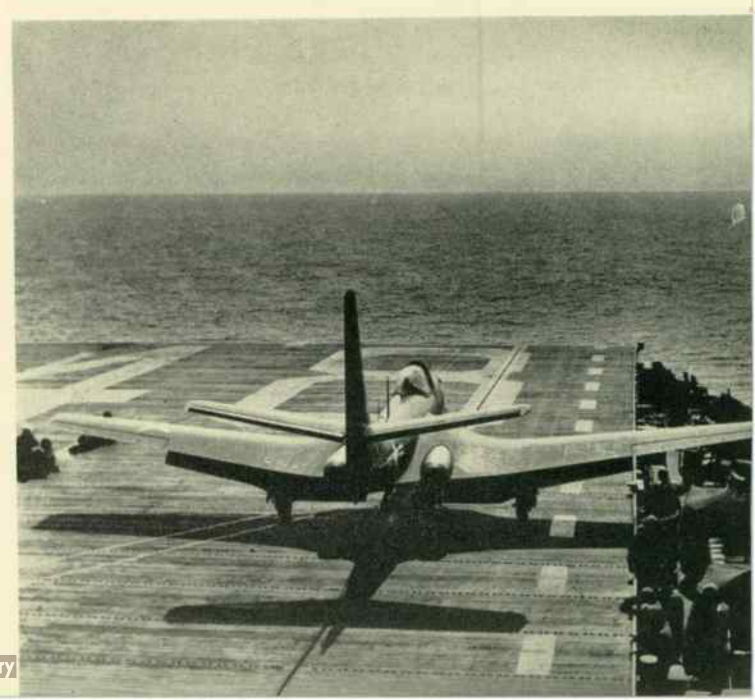
The gas-turbine drive has been reduced to pushbutton simplicity. Controls have been developed so that the operator, to start the unit, simply presses a button. The controls thereupon act automatically to start and accelerate the turbine by means of battery power, initiate combustion at the right time, and bring the unit up to idling speed. On repeated tests under different conditions the cold turbine has been brought from standstill to idling, ready to carry full load, in 1½ minutes.

The experimental gas turbine has performed so well on tests that, trials concluded, it is to be installed this spring at a pumping station on the natural-gas pipe line of the Mississippi River Fuel Corporation. Although the combustor and turbine will remain unchanged, a somewhat larger turbine compressor will be required and the gear and d-c generators will be replaced by a centrifugal gas booster to pump the gas. Initially the machine will burn liquid fuel, but subsequent modifications will enable it to take its fuel from the pipe line.

In addition to the two 2000-hp gas turbines being built for the locomotive, a larger unit of 4500 hp is being designed. It will be suitable either for locomotive or industrial service.

Another variant of the gas-turbine locomotive is being explored. It will employ a gas generator of the free-piston type developed by the Lima-Hamilton Corporation. In this type of unit two synchronized free pistons move shuttle-wise in a cylinder and do two things. They compress air for their own combustion chamber and exhaust hot, high-pressure gases to a gas turbine of conventional form, which is thus freed of the necessity of driving its own compressor. The first demonstration unit will have six free-piston gas generators, a gas turbine,

During recent jet-pilot qualifications on the carrier *U.S.S. Saipan*, 200 take-offs and landings were made by Westinghouse-equipped McDonnell Phantoms without any delays ascribable to power plants. Each of the 165 engine starts was completely normal.



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and conventional electric drive. The unit will be given its trials by the Pennsylvania Railroad.

A Progress Report on Jet Engines— Jet-propulsion gas turbines have continued to chalk up gains in two types of progress. One is in economy of fuel and dimensions, the other is in ability to meet stiffening service requirements. For example, the 24C engine currently in production develops nine percent more thrust with somewhat less fuel consumption than did the corresponding model of a year ago. On the basis of the amount of power for a given amount of fuel, the present engine is nearly a third better than the early models. Jet engine designers, looking to the future, believe they see in the engines of a few years hence another 25 percent betterment. If this is realized, the greatest handicap of the jet engine—fuel economy—will have been reduced by about one half in a ten-year period.

This improvement comes about by no single, radical change. In fact, the basic in-line arrangement of air inlet, axial-flow compressor, combustor, turbine, and exhaust remains exactly as engineers conceived it when the tragedy of Pearl Harbor was still ringing in their ears. This in-line engine still holds the palm for high installed efficiency and small frontal area. The engines are building up an excellent reliability record.

Factors contributing to the steady betterment in fuel economy are improved flow path and blade design, new materials for both blades and turbine discs, higher turbine temperatures, and a considerably improved combustion system that gives better temperature distribution.

In the beginning the problem was just to build a jet engine that would propel an airplane. Now the services are adding to that basic requirement many others of great severity. The lubricating oil system must function with large values of positive gravity, i.e., rapid upward acceleration, with zero gravity, or even negative gravity representing rapid descent. The engine must operate upside down or in an almost vertical climb. The engines must be able to operate with inlet air temperatures of 70 degrees below zero or 200 degrees above zero. This wide range in operating variables poses many special problems to the jet designer, particularly with respect to the lubricating and fuel systems and the materials that have to stand up under these conditions.

In addition to the engines now in production, improved models of the same engine, as well as newer and much larger engines, are in progress. Figures on these are not yet released.

Tough Turbine— Weather—good or bad—means nothing to the newest general-purpose turbine. Weather-protected construction and other features make the turbine suitable for all industries, indoors and outdoors, regardless of operating conditions and atmospheres, be they clean, dirty, dusty, corrosive, or moist. The turbine can operate under the worst conditions for long periods of time without attention.

The turbine is built in three different frame sizes and is available in ratings up to 1500 hp at speeds up to 7000 rpm. Maximum steam conditions are: inlet pressure, 1500 pounds per square inch; temperature, 950 degrees F; and exhaust pressure, 300 pounds.

The turbine support is an adaptation of the center-line type generally employed for central-station machines. The turbine has two supports: a rigid one at the coupling end, which anchors the unit but permits radial expansion of the casing, and a flexible one at the governor end, which flexes readily in an axial direction only. Because these supports are not a part of and are some distance from the turbine cylinder, their temperatures and hence dimensions vary little. As a result, alignment of the turbine shaft to the driven machine is maintained regardless of change in operating temperature. Maintenance of alignment is further enhanced by transmitting piping thrust to the foundation with a minimum of casing distortion through the temperature cycles.

An interesting feature of the turbine is dual overspeed protection. Normally, overspeed protection is provided by a single valve (operated independently of the main governor) that closes when speed becomes excessive. As this valve may not operate for long periods of time, under adverse conditions it may stick and fail to close when the need arises. Hence, as an added safety measure, dual protection was arranged, which closes the governor valve as well as the overspeed valve. The two valves function independently of each other.

Other features of the type-E turbine are corrosion-resistant casing glands that do not deteriorate during long periods of idleness, bearing-housing seals that are proof against virtually all external influences, and a governor lever arrangement that provides for four alternative positions of the fulcrum pins that increase the turbine's flexibility.

Westinghouse jet engines of the several models produced to date have been flown not only in many planes, but also in many types of planes. The newer ships now flying, or soon to fly, with these jet engines include a new McDonnell two-engine fighter (XF88) for the Air Force, the Chance-Vought Navy fighter (XF7U), the Douglas night fighter (F3D), Lockheed's ultra-fast (XF90), Northrop's (XS4), and the Curtiss-Wright all-weather four-engine fighter (P87). Below are a Navy Douglas Skyrocket, and a McDonnell "parasite" plane for the Air Force.

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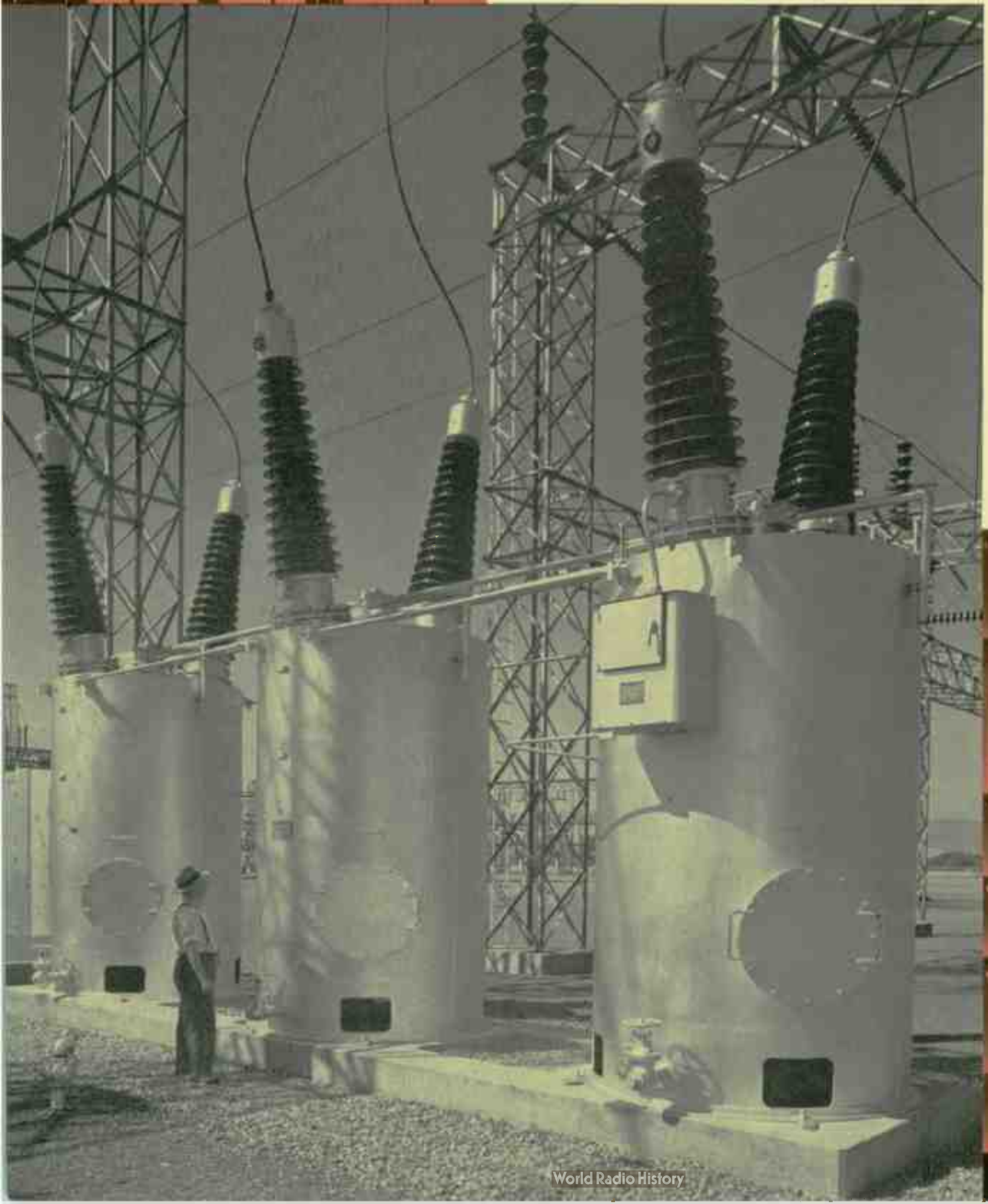
Transmission and Distribution of Power



A 230-kv, 3-cycle circuit breaker on the system of the Pacific Gas & Electric Co.; it is capable of interrupting 2½ million kva.

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The need to deliver larger and larger blocks of power has been the motivating force behind the long-term trend to higher voltages and greater system complexity. The advance to 220 kv was made about 25 years ago, just as engineers developed more confidence in their struggle with lightning. This has continued to be the maximum transmission voltage, with the single exception of the 287-kv line from Boulder Dam to Los Angeles. In these years lightning has ceased to be the limiting factor in transmission. Lines and equipment are now lightning-proof.

Other factors—corona, for one, in addition of course to economics—are the determining ones in selecting transmission voltages. The investigation of transmission at higher voltages has led to the experiments on the half-million-volt lines at Tidd Station under the general sponsorship of the American Gas and Electric Service Corporation.

These tests have now been running a year, but it is much too soon to expect detailed conclusions. The task, first of gathering data and second of correlating and interpreting it, is a long and unglamorous one. For example, in six months 65 different kinds of tests were made, requiring 60 000 readings on 18 different types of instruments. Each reading necessitated from one to four separate calculations. Nearly 150 000 inches (2⅓ miles) of chart records were taken. And the work is far from complete.

Transformer Behemoths— A year ago mention was made here of power transformers surpassing the hypothetical milestone of 100 000 kva. Now that mark has been far outdistanced. A 110 000-kva, 3-phase transformer is in service on the Buffalo-Niagara system. Soon to be installed is a 145 000-kva, 3-phase unit for Detroit Edison. This is the largest transformer (electrically and physically) ever shipped as a unit complete, except for bushings and radiators. It will step up from 15 kv to 135 kv (115-kv insulation level on a solidly grounded system). Forced-oil and forced-water cooled (FOW), it has coolers mounted separately in a room below the transformer itself, thus avoiding freezing hazards.

This continuing rise in transformer rating leads to the inquiry: "Just what is the upper limit in power transformers that can be built and shipped as a unit?" Since engineers are reluctant to recognize absolute ceilings, the answer given is equivocal. Recently, however, engineers did assert their willingness to undertake a 170 000-kva, 138-kv transformer, despite the fact that it was scheduled for service in an area with rather marked shipping limitations. Another even larger unit, of a quarter million kva, has been studied and found possible, subject to closer examination should serious interest develop in such a giant. In essence, power-transformer engineers feel that with the present well-established principles of construction—shell-form arrangement of core and coils, Hipersil steel, and form-fit tank—they are willing to undertake the construction and shipment, assembled, of any size transformer needed in the foreseeable future.

Mobile transformers are achieving giant size. Engineering studies have been made on a unit of 100 000 kva at 138 kv for permanent mounting on a railroad flatcar. It is felt that such a unit or others of comparable size at other voltages can be built if required. Such mobile giants could be quickly shunted to any railroad point on a system to serve in emergencies or while a unit is undergoing service. The transformer for a mobile unit would be of the shell-form construction, form-fit tank and would operate permanently in the horizontal position for reasons of railroad clearances.

Cooling methods are showing a noticeable trend to forced oil for transformers of high capacity. Instead of large radiator banks surrounding the tank, with air-blast fans to dispel the heat, the tank walls are smooth and the oil is forced by pumps through the core and coils and then through heat exchangers. These exchangers can be mounted in any convenient location —some distance away if necessary. By comparison with a self-cooled unit the rating can be increased by this scheme by about two thirds. The ground space occupied is reduced by a similar degree. Forced-oil cooling is most readily adaptable to the form-fit tank. With this type of tank the circulated oil must pass through the ducts in the core-and-coil assembly; with the core-form construction much of the circulated oil passed outside the core, between it and the tank wall, thus losing much of its effectiveness.

A significant improvement in cooler construction has been developed. Formerly tubes were made by winding and tinning copper fins onto steel tubing. Now copper tubes are made by raising the fins from the copper itself. The complete tube assembly is dipped in the protecting synthetic resin, which proved so effective on naval ordnance equipment during the war, and then baked. Thus the tube and fins are an integral unit, providing better heat transfer and eliminating the possibility of separation of fin and tube.

Where water is readily available at low cost, water cooling of transformers is attractive. A new oil-to-water heat exchanger for thermosyphon oil circulation has been developed to secure the benefits of this type of cooling at least cost. Instead of placing water coils within the tank, thereby complicating construction and incurring stubborn sealing problems, the heat exchangers are made as separate units for external mounting on the transformer. Thus maintenance of the cooler no longer involves opening the tank. A transformer with two or more such external coolers could continue in service at somewhat reduced capacity with one heat exchanger disconnected, or even removed entirely. To obtain the additional capacity resulting from forced-oil circulation, a pump can easily be added later.

Important simplifications have taken place in CSP power transformers. To meet the requirements for all kva's and voltages some 500 sets of core-and-coil designs and a similar number for tanks were required. By integration and careful planning these have been reduced to 40 core and coils and 15 tanks. The transformer is benefited by a new protective link, new pressure-relief device, and a new thermal relay. Air-insulated potential and current transformers and draw-out breakers are used. Provision likewise is made for bypassing the circuit breaker for maintenance. Because fewer drawings are required a given unit can be completed in less time.

More Avenues for Power-System Communication— Man has been remarkably ingenious in devising traffic avenues. But eventually the problem of congestion rises to harass the traffic engineer. This is as true in the field of communication as in that of vehicular traffic. It has now become a problem even with that specialized field of intelligence transmission employed by electric-power companies—generally known as power-line carrier. Because power systems have grown so extensive, so complex, and with so many interconnections between systems, and because of the tremendous increase in transmitted signals for conversation, relaying, supervision, the available high-frequency channels are insufficient.

One means of relieving this congestion is the scheme of single-sideband carriers, announced at the close of the war. Last year three of these installations were placed in service. The single-sideband system, in effect, approximately doubles the number of channels available. A further great advantage is that the circuit is less cluttered with extraneous noise be-

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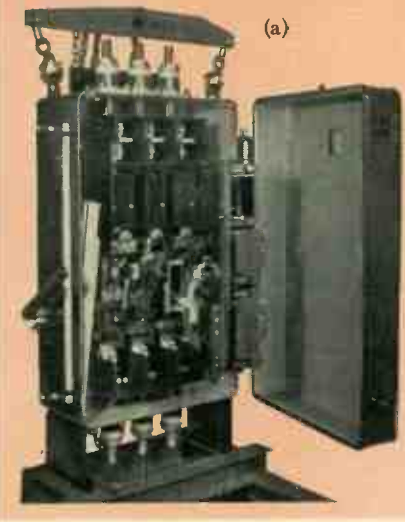
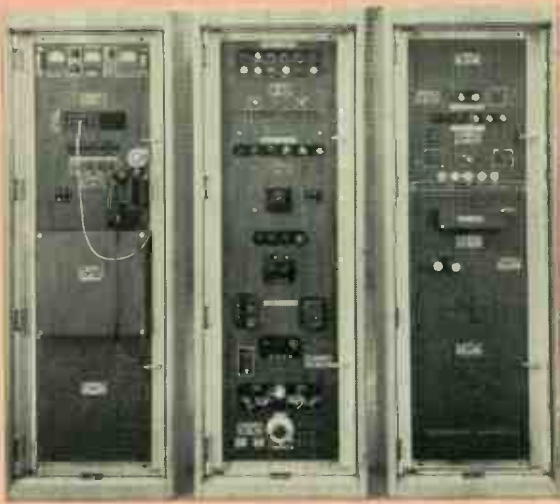


(a)

(a) The cover on this new heavy-duty network protector is held with 4 bolts instead of 28. (b) Single-sideband power-line carrier is one answer to channel congestion. (c) A new low-voltage circuit breaker sets a new standard in accessibility and use of standard, interchangeable subassemblies. (d) and (e) This small auxiliary instrument transformer can be used to measure either potential or current and can accommodate a wide variety of voltage and current ratios, as the tabulation on the nameplate indicates. Heretofore, combination voltage or current auxiliary transformers have not been available as a standard line, especially with multiple ratings. (f) This is a 300-kva, 4-kv; submersible, dry-type transformer in a basement vault of a theater.



(b)

cause the narrower channels have proportionately less interference. In contrast with the amplitude-modulation and frequency-modulation systems, the carrier frequency is suppressed. Only one of the two sideband frequencies is transmitted and it only when signals are being conveyed.

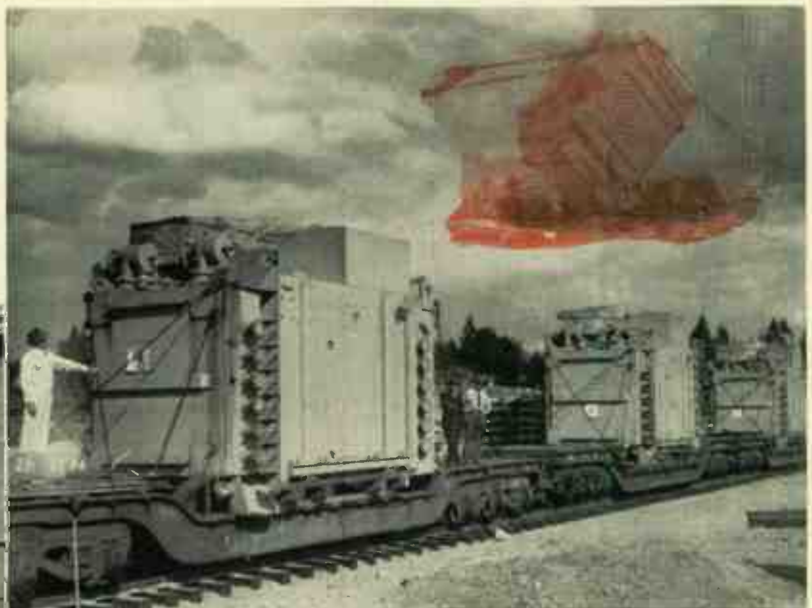
It is interesting to note that recently amateur radio "hams" have resorted to the single-sideband principle for the same reason—to reduce channel congestion.

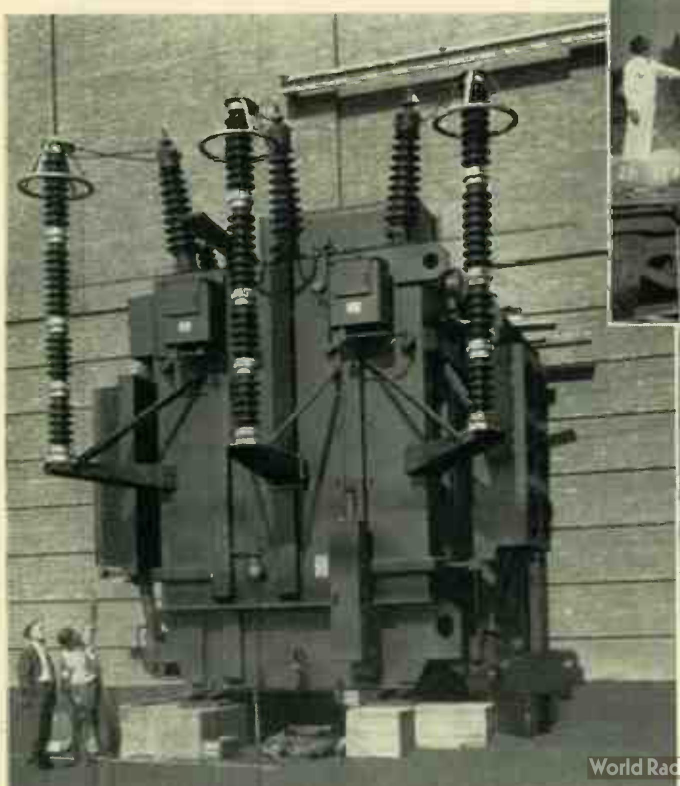
Not so well developed is another quite different tool expected to be a valuable aid to power companies with their growing communication load. It is microwave space radio, an outgrowth of radar. This system utilizes the highly directional properties of beamed ultra-high frequencies to transmit signals through the air with extremely small energies. A few watts are ample for a microwave transmission of several channels in the 950-megacycle region over 20 to 40 miles.

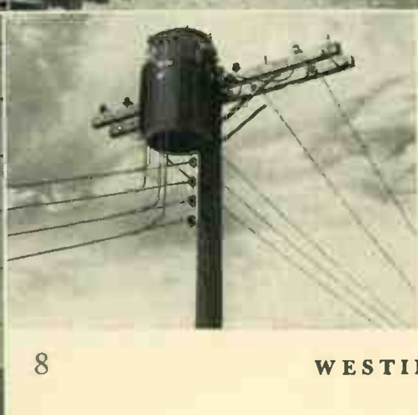
Two sets of microwave equipment for power-line use will be given their trials this spring. Each set will provide four voice channels, not the ultimate possible however. When required, tones can be transmitted in wide-frequency voice bands for relaying, supervising, and telemetering signals. Each set could provide some 40 separate avenues for transmission of system operation information.

Microwave radio, still in its earliest development stages for power-system communication, is expected to supplement, not to replace, wire-borne carrier. Its straight-line directional property is both its strength and its weakness. It reduces the power required to send a signal to a few watts but limits the range to approximately line-of-sight distances, or some 20 to 40 miles. Thus transmission over hundreds of miles entails frequent repeater stations, which are costly in money and signal quality. Microwave radio will more likely be used to

The 83 333-kva, single-phase transformers for the Snohomish Substation on the 220-kv Bonneville system were shipped completely assembled, except for bushings and radiators, but lying on their sides. Hoisting to vertical position on the site was accomplished by simple rigging and block and tackle as the insert in color shows. Below is the huge 110 000-kva, three-phase transformer in service at the Huntley station of the Buffalo Niagara Electric Corporation. →







← This is a three-phase CSP transformer on the system of the Connecticut Light and Power Company. Three-phase CSP and CSPB transformers up to 75 kva have been made possible by the new circuit breaker (BR) which can be ganged for three-phase power distribution.

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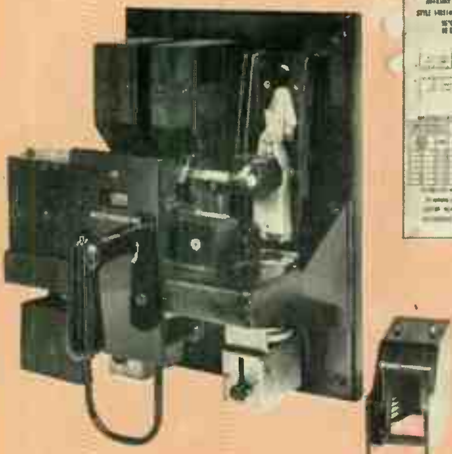

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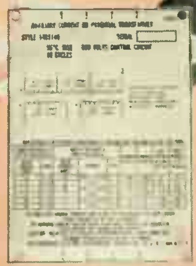

(d)

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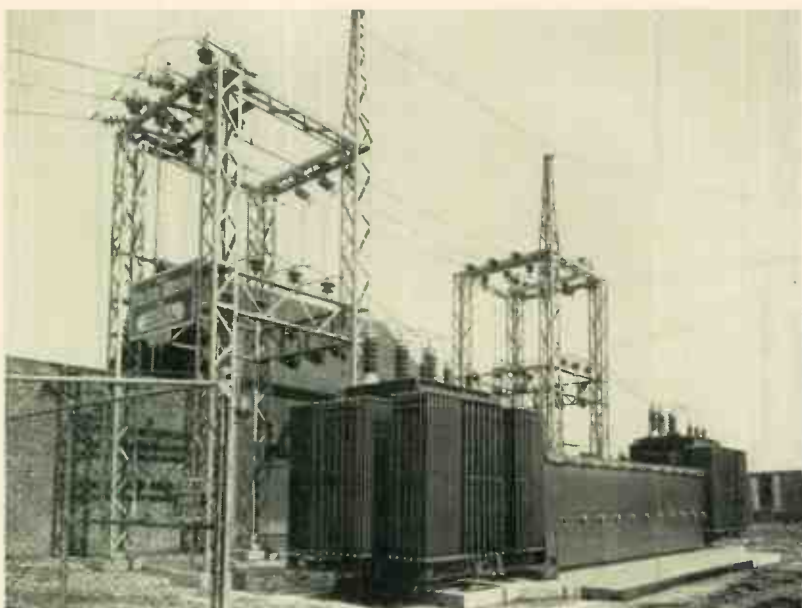
cover short jumps in systems to pass crowded carriers or to fill in gaps. It can also be used to interconnect two power systems where each system has its own carrier; in such a case direct connection of the systems would result in interference between power-line carrier channels. Or microwave radio can be the link between a downtown dispatching point and the transmission system several miles away.

Other uses are envisioned for microwave equipment in addition to those of power companies. It is well adapted for communication between forest-ranger stations and for communication between stations along pipe lines or between drilling points, by petroleum companies—particularly for off-shore drilling. Police and fire agencies could also possibly use microwave radio between central control stations and transmitters placed more advantageously some distance away from the control point.

More Kva Interrupted. Same Tanks— The major trend in circuit interruption was signalized over a year ago by demonstration at Grand Coulee that the interrupting capacity ceiling at 230 kv could be raised from 3½ million kva to at least 7½ million and perhaps 10 million. And without increase in physical size of the breakers. This trend, furthermore, is not confined to this highest voltage class of oil breakers. The circuit-interrupting ability of 138-kv, 3- and 5-cycle breakers has been raised from a top of 3½ to 5 million kva. Likewise a breaker is being built for 69 kv that has an interrupting rating of 3½ million kva, one million more than heretofore possible at this voltage. This is being accomplished by employing the multiflow De-ion grid principle, developed for high voltages. This type of interrupter, while more costly to build than the magnetic De-ion interrupter, is better adapted to high-voltage arc interruption. The 69-kv breaker has another severe re-



← When a utility or industry engineer needs a substation he buys only one thing—a coordinated substation. He has to furnish separately only the ground, foundations, fence, and padlock. All transforming, switching, protecting, and terminating apparatus and overhead steel supports are designed and furnished as a unit. Below is an oil-filled, single-phase, current-limiting reactor for unusually high voltage—138 kv. Rated at 11 136 kva, it has a 13.9-kv drop at 800 amperes. ↓

Here is a picture of a transformer installation! The practice of concealing distribution transformers in semi-buried housings with below-surface cable has merit for residential districts where freedom from overhead construction is an important appearance consideration. →

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quirement to meet in that the continuous current rating is being raised from 1200 amperes to 2000, which requires an entirely new main-contact construction. In all these cases the enlarged rating is obtained with no increase in tank size.

A new feature, previously available only at 230 kv, is being added to the 138-kv breaker for 3-cycle ratings. This 3-cycle breaker is to have a spring-driven supplementary oil-flow piston that will assist in interrupting charging currents. This piston will be inactive during interruption of heavy short circuits, as the strong gas pressures developed will actually prevent its movement. However, immediately after the arc pressure subsides it will operate and provide a valuable flushing function.

Work continues on the breakers for ten million kva for the Grand Coulee system. These are the outgrowth of the high-capacity tests. Much has been done to simplify and strengthen the operating mechanism, but no basic change in the interrupter principle is indicated, even for this enormous rating. Although these breakers will carry an official rating of ten million kva, the Grand Coulee authorities have indicated the probability that the breakers, after being placed in service, will be tested at even higher kva's, perhaps 12 million.

Better Low-Voltage Air Circuit Breakers— Growing out of the wartime work done on air-insulated circuit-interruption devices, particularly for shipboard use, is a much improved low-voltage air circuit breaker. This breaker is created for service on industrial feeder and motor circuits at 600 volts, 3 phase, or 250 volts, direct current. The continuous current ratings are 225 and 600 amperes and the corresponding interrupting capacities are 15 000 and 25 000 amperes. This new breaker has four outstanding improvements over previous designs for similar application. First, subassembly construction has been carried to an extreme degree. The operating mechanism, shunt trip, auxiliary switches, closing solenoid, pole units, and trip units, for example, are separate units and are complete subassemblies that can be individually stocked to facilitate quick grouping of any desired combination of parts. Furthermore, such an arrangement facilitates interchangeability and replacement of subassemblies in the field.

The complete group of basic elements to build a particular breaker are mounted on a new kind of chassis, which is the second feature of the new breaker. This chassis consists of a grounded metal shelf extending from a vertical grounded-metal plate. The current-carrying parts of each pole unit are assembled in a molded insulating piece, which, in turn, is mounted on the steel panel. This grounded frame reduces the insulation required when applied either to a dead-front panel or draw-out form and increases the safety to servicemen.

The third feature of the design is the standardization of the complete breaker. A single standardized breaker unit is readily adaptable to (1) draw-out, metal-clad construction, (2) fixed breaker dead-front, metal-clad construction, or (3) separately enclosed individual mounting in a wide variety of enclosures for specialized application.

Last is the interchangeable overcurrent trip device that combines characteristics for either general-purpose or motor-starting applications. Each overcurrent device on a given frame size breaker is completely interchangeable with other ratings. This facilitates calibration changes in the field.

Network Protectors Give New Meaning to Heavy Duty— The new heavy-duty network protector is capable of heavier duty as far as electrical performance is concerned, but imposes a lighter duty on the serviceman. Without increasing the weight or dimensions, the maximum rating of the heavy-duty network protector has been lifted from 40 000 amperes at 480 volts to 60 000 amperes, 600 volts. Smaller units show similar increases. This substantial increase in interrupting rating is in keeping with the heavier loads being added to heavy-density networks. It is achieved by new-type contacts on the circuit breaker and an improved interrupter.

Network protectors, because they are located below the streets, must be watertight and are tested at 6½ pounds pressure. The heavy steel doors in older units were seated against hard gaskets with bolts spaced five inches apart—necessitating removal of 28 bolts to gain access to the mechanism. The new protector employs neoprene as a soft, tubular gasket that provides adequate tightness with only two bolts. The gasket is gripped in a retainer ring so that not even the usual cement is required. Another gain for synthetic rubber!

A Good Arrester for CSP Transformers Made Better— Many devices could have been stopped in development years ago and yet be very satisfactory today. But, fortunately, technology doesn't "play" that way. Take arresters for completely self-protecting distribution transformers, for example. A million and three quarters of these have been made and have gathered over eight million arrester-years of service. The failure rate is such that the average power company in the United States with 3000 in service might experience not more than one failure in five years.

Be that as it may, an improved De-ion arrester for CSP transformers introduced last year is superior in several ways even if the service record can scarcely be bettered. It is simpler, because the supplemental external resistor is no longer required. The nominal voltage rating has been increased from 7200 to 9000 volts. The sparkover voltage of the old arrester gave ample protection on the CSP transformer; however the new arrester gives an even greater protection because its sparkover has been reduced as much as 20 kv.

The new arrester consists of a loose stack of alternate fiber rings and slotted fiber discs assembled between two electrodes and contained in a very slightly larger fiber tube enclosed in a porcelain housing. The construction employs the principle of extinguishing an arc by forcing it through multiple paths having large gas-producing areas. The advantage of the large areas of fiber exposed to the arc is that large volumes of cool un-ionized gas are provided at substantial pressures to extinguish the arc quickly at either high or low 60-cycle power-follow currents. The new arresters are interchangeable with those previously made. They will be available for all standard voltages within the near future.

Measuring Heavy Direct Currents— A static d-c transformer, like perpetual motion, has long been a sought-after impossibility. A new device called a Transductor comes close, achieving the same objective for one special purpose. It provides a safer way of measuring heavy direct currents.

In electrolytic plants, where currents of many thousands of amperes flow in a single bus, the traditional method of metering is to use a shunt and measure its voltage drop. Often this means long leads and placing the full bus voltage to ground on the meter. Both are sources of trouble and an actual hazard. With the Transductor the massive shunt is replaced by a special current transformer of the through type. The secondary winding is energized by alternating current of some convenient low potential—say 110 volts. A change in direct current affects the reluctance of the Transductor magnetic circuit and, in turn, the current flowing in its a-c circuit. This alternating current is measured on an a-c ammeter calibrated in direct current. Its accuracy is ½ percent.

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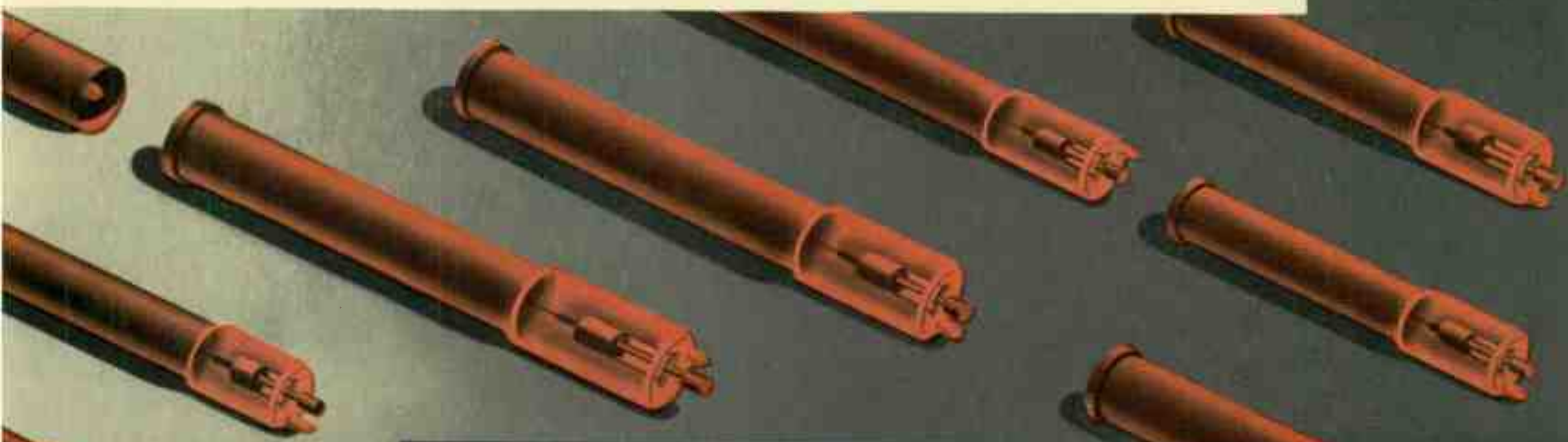
Lighting and Electronics

Being contemplated by a lamp expert are several experimental new fluorescent-mercury lamp forms. The phosphor used transforms some of the ultraviolet light to red, giving improved color quality without loss of efficiency. The background illustration shows some of the new mass-produced radiation-detection tubes.



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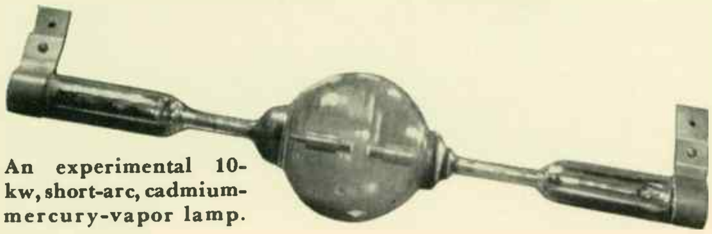


An experimental 10-kw, short-arc, cadmium-mercury-vapor lamp.

THE engineering developments of lamps, illumination, radio and x-ray have been separate and independent. But they do have a common ground; all have to do with the generation and use of electromagnetic radiation. Each has grown from a single-stem beginning into many varied forms and with functions far from the original. In the field of light sources, for example, the incandescent lamp stood almost alone until just a little more than a decade ago. Arcs and vapors had been used, but relatively little until about 1935. Since then two new light sources have grown and diversified with great rapidity—the metal vapor lamp and its variant, the fluorescent lamp.

Developments in Mercury Lamps and Their Uses—

Mercury vapor as a light source is improving in performance, increasing in popularity, and spreading to new uses. The sodium vapor light has, on the other hand, not prospered to like degree. Few new applications for it have appeared probably because, by comparison with mercury, its advantage in efficiency is opposed by its color characteristic and relatively large light source. In fact, some sodium lamps are being replaced with mercury, as at the traffic interchanges and tunnel entrances on Pennsylvania's famed turnpike. The mercury unit being applied there is the new horizontal oval-reflector using the 400-watt mercury lamp with extraordinary efficiency, developed originally for street-lighting purposes (OV20).

Not only are mercury-light sources stepping out to new forms but the performance of the older types has been bettered. The life of both the 250-watt and the 400-watt units has been extended from 3000 hours to 4000 hours at 10 hours per start. Also the lumen output of the larger lamp has been stepped up by 5 percent. These improvements come about as the result of improved production techniques.

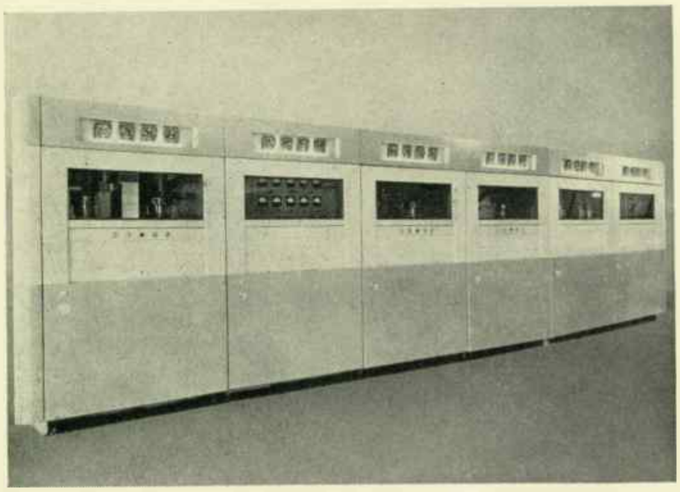
The mercury lamp and oval reflector (OV20), originally intended for streets and highways, is finding its way into other fields. It is proving an excellent source of uniform, high-quality light for the servicing platforms between passenger cars in railroad terminals. Also it has recently been applied for lighting of canals and locks. In a comparative test of sodium-vapor, mercury-vapor, and incandescent units along the Chesapeake and Delaware Canal, the mercury units permitted best discrimination between bank and waterline and allowed the best judgment of distance under all conditions of water level and weather, and gave the least offense from glare.

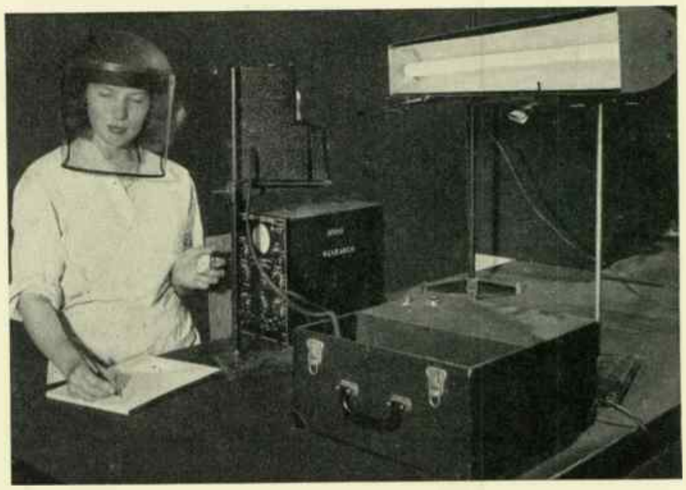
The extremely interesting use of mercury-produced light to initiate or hasten chemical action is growing. This use, akin to the creation of chlorophyl by the sun, has been most recently applied as the heart of a new method of shrink-proofing wool. The 3000-watt lamp is used for this work.

The mercury-vapor lamp has also found its way into television. It provides the extremely high level of illumination required with least heat, which is one of the most serious television studio problems. There is a reduction in heat because the lamp's color nearly coincides with the peak sensitivity of the tube used in certain types of scanning cameras. The Du-

New Radio Transmitters **embody many of the lessons learned in several unrelated fields. In the 50-kw AM transmitter the rectifier tubes and the separate cubicle that housed them have been replaced with metal-disc rectifiers, which have longer life and occupy somewhat less space. They are contained in the transmitter section. The designers borrowed from switchgear engineers the basic features of standard metal-clad cabinets perfected in power-plant service. Likewise standard circuit breakers, as used in steel mills, are employed. The transformers are all air cooled, eliminating oil, and because their magnetic cores are of Hipersil, as developed for distribution transformers, they are about one fourth smaller than their former counterparts. Extended supervisory control to track down trouble spots immediately is provided in greater degree than before. The 50-kw FM transmitter, following the building-block pattern established for FM equipment, consists of a 10-kw transmitter with a newly developed 50-kw final amplifier that weighs 98 pounds instead of 225. The design features simplified tuning with three adjustable amplifier tuning elements.**

A New Fluorescent Sunlamp **operating on a wholly new principle extends the use of artificial "suns" so that they are more adaptable to large groups of people. This new fluorescent lamp has a phosphor that transforms most of the invisible radiation created in the mercury vapor into erythemic and vitamin-D-producing rays, instead of visible rays. Only recently has a phosphor been developed that can produce such radiation so efficiently. The peak emission of this phosphor is at 3100 Angstroms, which is close to the maximum sensitivity of the human skin for the formation of erythema, tanning, and vitamin D. Because of its high efficiency the power cost is relatively small. Using only 40 watts it delivers 5½ times as much sun-tanning radiation as the type RS lamp does with 275 watts. The lamp can be used in the treatment of people who work long periods in the absence of sunlight, such as miners; as a therapeutic lamp in hospitals; in artificial solaria in resorts, hotels, etc.; in school rooms, offices, and factories; and in poultry houses, barns, and kennels. It is useful, in general, where a wide distribution of erythemic radiation is desired at little cost.**





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mont Television Studio WTTG, in Washington, D. C., began using mercury-vapor lamps for studio work early last year.

The development, mentioned a year ago, of mercury-vapor light sources suitable for motion-picture studio lighting has continued. The object has been to provide a self-contained light source of high efficiency that will avoid the smoke, hissing, and high maintenance that characterize the long-used open carbon arcs. The mercury-lamp development has two aspects—to improve the color quality and to concentrate more energy into smaller arcs. Two approaches are being made to the color problem. One is to provide the red missing from the mercury spectrum by adding a small amount of cadmium to the mercury (at some sacrifice in efficiency) or by using a phosphor that converts the unused ultraviolet of the mercury spectrum into visible, as described below. Both are being actively pursued and show promise. Aimed at providing the concentrated light source needed for movie-set work the lamp-development laboratory is experimenting with air-cooled mercury lamps of up to ten kilowatts in which the arcs are no larger than a peanut.

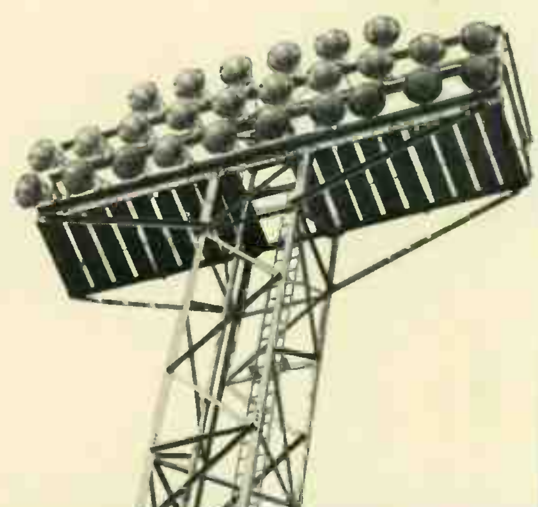
Mercury Lamps Are in the Red— The mercury-vapor lamp, for all its high efficiency—50 lumens per watt for the 400-watt size as against the filament lamp's 20—has been plagued by a deficiency. Its radiation spectrum, having no red and but little blue-green, produces the familiar color unflattering to human complexions.

A new approach gives promise of correcting this problem to a large degree. It uses something created by the mercury-vapor lamp itself but "thrown away" as waste—the invisible ultraviolet radiation, which is nearly a third of the total. The new scheme is to coat the inside of the outer glass envelope of the lamp with a phosphor that converts part of this invisible radiation into red light. This new light source actually combines the principles of both the mercury-vapor and the fluorescent lamps, to produce a light better than either.

This possibility has long been apparent to vapor-lamp engineers. The trick has been to find the right phosphor. Out of the thousands available, phosphor research men had to find one that met three difficult requirements: (1) it must pass efficiently the generated light already visible, (2) it must convert some part of all the many ultraviolet lines into visible light of a color in which mercury is deficient, and (3) the phosphor must be able to withstand heat, which requirement is the tough one to meet. It can be circumvented to some extent by building the bulb larger, and thus with more cooling surface, but to hold the bulb to a respectable size the phosphor must be able to withstand at least 250 degrees C. A phosphor has been found that meets all the requirements. Research men hope for still higher temperatures, which would make smaller bulbs possible. Although the development is only nicely underway, a test lamp has been operating with 11 percent of the total light in the red region. The phosphor does not limit unduly the passage of visible light so the efficiency is substantially the same as the ordinary mercury-vapor lamp. In other words, some of the light produced directly by the mercury discharge and absorbed by the phosphor is compensated by the conversion of ultraviolet to red. Research men hope that eventually the color-corrected lamp will be even more efficient than present mercury-vapor lamps.

***Lights that Penetrate Fog*— The system of man-made lightning flashes that enables a plane to land in even the worst fog has entered the next logical development phase—full-scale installation. One set of lights (below) is in operation at New York's International Airport. Another is functioning at the Landing Aids Experimental Station, Arcata, California, chosen because of its dubious distinction of possessing the nation's worst fog conditions. A third is being installed by the Air Force at its Clinton County (Ohio) Air Base, seat of automatic flight testing. The experimental installation at Cleveland Municipal Airport is being extended from six units to 22, being limited by the ground available. A full-scale installation requires 72 alternately spaced krypton and neon units that can be burned at relatively low intensity in fair weather or flashed intermittently at nine times the sun's brilliance to obtain intense, piercing pencils of light during overcast periods. Intermediate intensities are possible. The system enables pilots to make safe landings when all else is blotted out by fog, as has been given definite dramatic proof on several unrehearsed occasions.**

***Well-Directed Light*— To obtain bright and uniform lighting of football fields with floodlights placed a long distance away, a new sports light, in a parabolic reflector, has been developed that throws a narrow, concentrated beam of high candlepower. The reflector is large in diameter, which reduces the light lost around its periphery. The view of the Allentown (Pa.) High School field shows the remarkable degree of light control.**



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Fluorescent Lamps Take New, More Efficient Forms—A variety of improvements and additions embellish the broadening panorama of light sources. This is particularly true in the fluorescent group. An efficiency improvement, resulting in the main from the use of krypton instead of argon as the lamp atmosphere, is effecting changes of significance in lamp ratings and physical sizes. The voltage drop through krypton is less than for argon, hence the heating loss for a given current is less. As a result of this change a 25-watt, 33-inch lamp has been introduced that is important in two respects. It produces 52 percent more light for only 25 percent more energy input than the previous 20-watt, 24-inch lamp commonly used for home applications. Also the lamp employs the inexpensive reactor-type ballast instead of the transformer type still required by lamps of 30 watts or more.

Until recently krypton had not been given much consideration for fluorescent lamps because of its high cost. While it is still far more costly than argon the cost is declining, curiously enough, because of developments in welding. The rapid, war-hastened use of argon as an inert atmosphere for alloy arc welding resulted in low-cost methods of argon production with krypton as a by-product.

Krypton is also responsible for another new fluorescent lamp. It is an 85-watt lamp that has the same light output as the old 100-watt argon-filled lamp in the same size tube.

The fluorescent lamp gave fixture designers and architects a long light source of low brightness per unit area. The desire for long, slender "ribbons of light" has led to very long lamps, called Slimline. Lamps 3½, 5⅓, 6, and 8 feet long have been increasingly popular, especially in connection with modern architecture. They are efficient, economical, and start instantly without separate starters.

To utilize these long lines of light, various new fixtures for both industry and office have been developed. A new factory luminaire mounts four of the 96-inch lamps. The luminaires are so constructed that several can be arranged end to end to give continuous lines of light.

The eight-foot fluorescent lamp formerly was made only in the 69-watt rating. To meet the demand for more light per foot the lamp diameter has been increased by one-half inch to provide a 96-watt unit. This improves lighting economy and still provides instant-start operation without the use of separate starting devices.

The first digression made in the shape of fluorescent lamps was to the circle, a couple of years ago. This has been followed by the half circle, which is more practical to manufacture and permits two to be placed together around a column or other object, and permits a two-step control of intensity desired for many home uses.

Midget of the fluorescent lamp family is one of golf-ball size and shape. Because it consumes only one watt of energy it is useful as a night light in halls, corridors, stair landings, bathrooms and elsewhere where a small amount of light is sufficient for safety at night. Even burning for a year continuously, it consumes less than ten kilowatthours or about a quarter's worth of electricity. This novel lamp was developed just as the war began but has only recently been made available in quantity.

The fluorescent lamp, clearly, is following the pattern of the incandescent lamp—continuous improvements and a diversification of varieties and sizes. More than 160 combinations of lamps and colors are now available and others are being developed to meet new needs. The newest is the eight-foot krypton lamp now being perfected. It will operate on a preheat starting circuit and have extremely high overall efficiency.

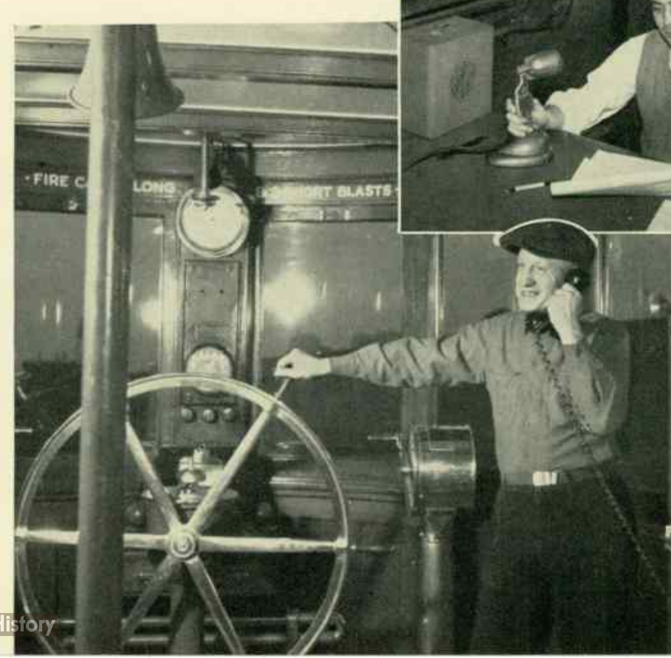
New Tools for a New Era—An age is known by its tools. On that basis the atomic age is here. The Geiger counter, heretofore a hand-made device put together by the physicist interested in studying cosmic radiation or searching for misplaced radium, is being readied for mass production. Developments are under way that will lead to economical precision manufacturing of tubes, instruments, and power supplies for Geiger counters by the tens of thousands, like components of radio receivers. They will appear in a variety of forms.

The growing availability of man-made isotopes has created a need for nuclear radiation counters for medical research, for tracer studies, and for process control in industry. In university and atomic-energy research laboratories these counters will become as common as voltmeters. Should atomic energy be developed for industrial uses, radiation detection in many forms will be required for personnel protection.

A closer and grimmer need is that of the military forces as they take the possibility of atomic warfare into account. If this country should be attacked by any one of many conceivable weapons—atomic-energy bombs, radioactive dust, or an infiltration of radiation-poison packages, large quantities of detectors would be required throughout populous centers. Dour thought—but a radiation detector may be standard equipment for the civilian-defense crewman of the future.

One of the representative new types is a cylinder of chrome steel about an inch in diameter and six inches long. Through a glass insulator at one end a heavy wire extends down the center of the tube to almost the far end, which is covered by a wafer of mica that must be only one half of one thousandth of an inch thick. One critical feature of the tube is the gas within it. A precisely controlled mixture of neon, argon, and an exact trace of chlorine, at something less than atmospheric pressure, has proved ideal. The chlorine, a chemically active gas and difficult to control, is essential. Its function is to hasten deionization after each "count" before another beta particle or gamma ray enters. The central wire is maintained positive while the metal cylinder is negative. A beta particle (electron) or gamma ray entering through the mica window ionizes some of the gas, causing a discharge between wire and wall. This

FM radio piles up economies fast in tugboat operation. In one installation in New York harbor it was responsible for a 13-percent increase in work done per tugboat hour. About 250 tugboat hours were saved in a representative month of FM radio operation.



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order of performance from paper-making machines. For example, the electronic speed regulator recently introduced to steel mills was originally developed for use with paper-making machines to maintain exact synchronization between the sections of the machines that are designed for turning out paper at speeds up to 2000 feet per minute. Several of these have been in operation a sufficient time to give good evidence that the electronic regulator will be preferred to the other types.

The electronic regulator, like any new device had its share of early "bugs," but it has given a remarkable account of itself as illustrated by the start-up of a new high-speed kraft mill. The machine was started and commercial paper was obtained from the initial run. Such a performance had been unheard of in the industry. It is a sign of two things: that electronic controls are not only ready for industry, but also that industry is ready for electronic controls. Heavy industries are adding to their staffs men who understand and can obtain from electronic controls the good performance of which they are capable. The exposure of great numbers of men during the war to electronic devices is in large measure responsible for the availability of such technicians.

Another conspicuous movement in the paper industry is the extension of sectional drive to a variety of special product machines. Heretofore it has been largely limited to machines making kraft, book papers, and newsprint. Last year individual motor drives were placed on the wet or paper-forming end of two large cylinder-type machines of the U. S. Gypsum Company. Sectional drive has also been applied to a machine making paper-base shingles. Sectional drive brings to such machines an increased flexibility to permit a wider variety of product and a larger machine output.

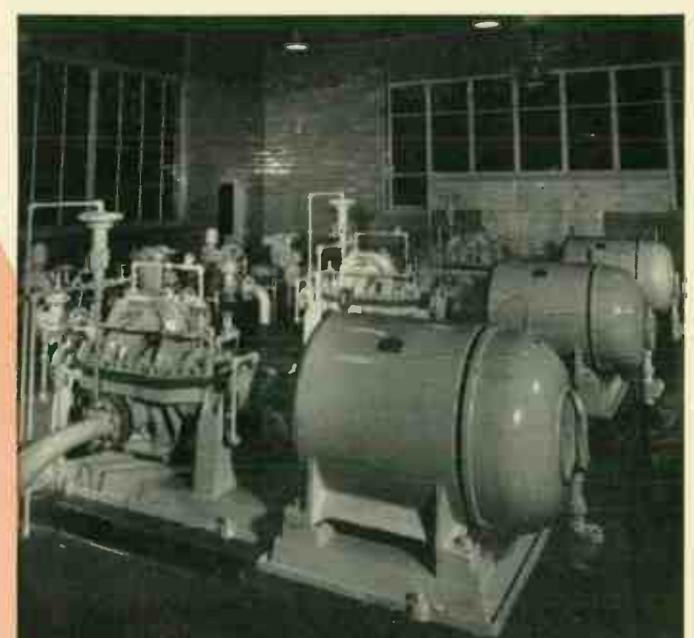
New Drives for Textiles—Some machines in the textile industry are giving up line-shaft drive in favor of synchronized motors on the separate components. For example, a new combination dyeing and sizing machine has individual motors with Rototrol tension control to perform a multiplicity of sequence operations—to dye the yarn, followed by drying, curing, oxidizing, washing, sizing, drying and winding the yarn ready for the loom. A new drive similar to that for a slasher (applies size to yarn) maintains constant tension at the wind-up beam. Continuous operation is maintained during beam changes, thereby reducing the waste that comes from change in color when the yarn is stopped in the dye vat. Rototrol has been applied to a new rug-cleaning machine to maintain matched speeds between washer and dryer sections, so that your favorite 9 by 12 rug remains 9 by 12 after it has been cleaned.

To increase productivity, a machine to cut fabric on a bias for tire casings was equipped with adjustable-voltage drive with photoelectric relays to control the cycle that includes up to 30 stops, accurate cutting, and restarting each minute.

Indicative of the severity of control problems posed in modern manufacturing is that the speed of a synthetic-textile yarn-spinning machine was required to be held within one-tenth percent of a preselected value over the entire speed range of about six to one. Change in machine speed is directly reflected in change in filament diameter, which in a finished material may show as an irregular and unwanted pattern due

A motor for food plants must take a lot of water, and here the new one gets it. *Below* various members of the Lifeline motor family pose for their picture. The types are: sanitary, wound-rotor, oil-well, explosion-proof, fan-cooled, and splash-proof. The family resemblance throughout is apparent.

These totally enclosed, fan-cooled motors driving pumps on a mid-west oil line help deliver more fuel to the populous industrial East.



discharge is registered as a click on an audible-type instrument or by a needle if visual indication is desired. The sensitivity of the tube and circuit is astonishing.

Radiation detectors require new meters. One recently developed and now being manufactured has four scales of sensitivity, each with an appropriate color band, indicating intensities of radiation as to safe, mild, or hazardous. The emphasis has been to provide meters with adequate sensitivity and maximum reliability, sturdiness, and compactness. Fortunately one of the basic instrument mechanisms developed to meet the severe requirements of World War II could be adapted. The development was thus to adopt this mechanism in a complete instrument to fit in with the many other components, and at the same time provide the means for operation and use of the overall detecting device. Radiac instruments (as radiation detection equipment is now called) will appear in various forms, from large units, for bringing indications from remote places to a central point, to outfits that a man can carry with ease. Use of the tiny high-voltage batteries, tubes, and other components as developed for hearing aids and similar sets requiring the utmost in small size will help hold the total weight of the portable unit to not over ten pounds.

Industrial Radio Pays Off— Modern train dispatchers no longer have frustration complexes from trying vainly to issue new instructions to switchmen miles distant. Neither do tugboat dispatchers. Industrial radio for over two years has provided a simple means of regulating train movements with outstanding success. With radio, a railroad dispatcher can shift trains and coordinate switching operations with a minimum of time and effort. FM radio sets have proved to be tremendous time savers and have found use in many types of railroad applications. They have proved especially valuable in switching operations on industry-owned roads.

A second major use for industrial radio has been found in tugboat dispatching. Tugboat captains are even harder to reach than railroad engineers, and in most cases it was necessary to have tugs return to a central dispatching point to pick up further orders. A change in orders was possible only if the tug captain happened to call the dispatcher by telephone from some land point. With radio dispatching, orders can be changed at a moment's notice if necessary, and tugs can go directly from one job to another, avoiding light runs back to the nearest telephone or to the dispatcher.

Electronic Heating Grows—Electronics was given its introduction to the steel industry in a big way during the war when some 9000 kw of radio-frequency generators were installed for flowing tin. This was a tin-saving necessity, with economics a secondary consideration. Now, even with costs again a dominant factor, r-f heating in tin-plate manufacturing is showing superlative staying power. To keep up with the increase in speed of the Weirton Steel Company tin-plate mill, 600 kw in r-f generators is being added to the original system.

An increase of 50 percent in tin-plate-making capacity in this country is expected within the next five years. Radio-frequency heating is being considered as the preferred method of tin heating, either solely or in cooperation with other heat, for a large proportion of the expanded and new facilities.

Radio-frequency heating generally continues to grow in a large way as a basic tool of industry. A sufficient mass of data and actual experience in both induction and dielectric heating has been accumulated that the suitability as a method of heating for a given part is no longer a matter of trial. This is reducing by a large factor the experimental work necessary, leaving more time for exploration of application details.

Radio-frequency heating is rapidly becoming an integrated system, applied as such, instead of as separate components. This has led to fuller coordination of the r-f generator and the work-handling equipment. This is particularly apparent in the wood-gluing industry where generators and presses are being planned as a unit. For induction hardening, basic types of work-handling apparatus are being developed for integration directly with the high-frequency generator. Wood gluing, curing of large masses of sponge rubber, metal joining (brazing, soldering, etc.), and selective hardening continue to be the principal uses for r-f heat.

An outstanding installation of induction-heating apparatus was made during 1948 in the Louisville plant of the International Harvester Company for hardening tractor gears. Here the whole plant production is predicated on induction heating. No substitute heat-treating facilities or space for them is available. The installation, furthermore, is an interesting combination of both low and radio frequencies. The gears proceed to the induction-hardening center on a conveyor and return on the same conveyor without handling or human attention. Each gear enters a coil supplied at 906 kilocycles by a 150-kw rotating generator. This brings the outer rim and teeth of the gear up to about 1200 degrees F. The surface is then brought quickly up to hardening point by a 200-kw, 450-kilocycle generator, after which a 50-kw, 10 kilocycle generator applies heat during a controlled "soaking" or cooling period. Production rates up to 700 hardened gears per hour are obtained.

This setup has proved to have many advantages over carburizing. The hardening is more uniform and more selective. Copper plating or special quench fixtures to protect certain areas during hardening are unnecessary. The time gears spend in the hardening department has been reduced from days to seconds, which has a salutory effect on inventory and storage space, and has other production benefits.

A manufacturer of forges proposes to furnish r-f heating to eliminate the conventional furnace for heating the parts to be forged. The reduced heating time results in less oxidation and, consequently, less scale formation.

The high-speed x-ray motion picture device has gone from the seeming disarray of apparatus that characterizes many research setups to neat, compact cabinets, operated by pushbuttons. Film speeds are 50, 100, or 150 frames per second; exposures, each 10 micro-seconds.

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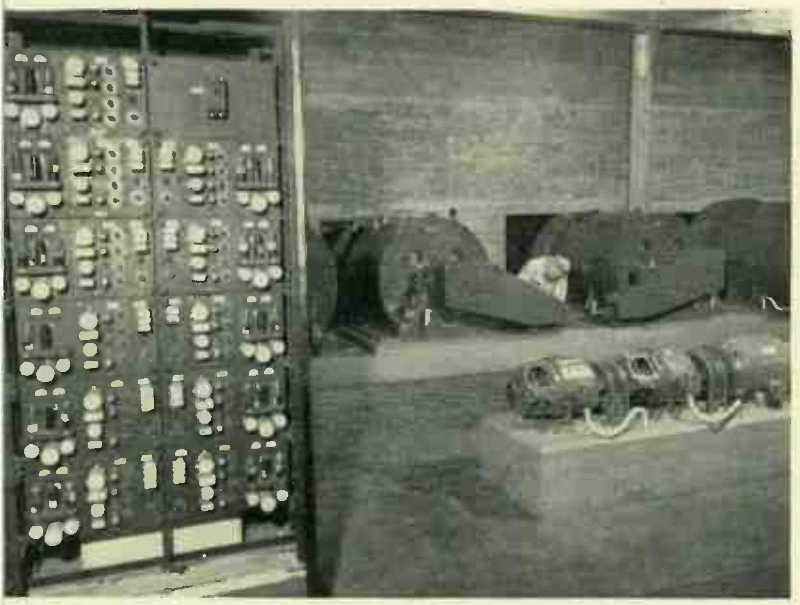
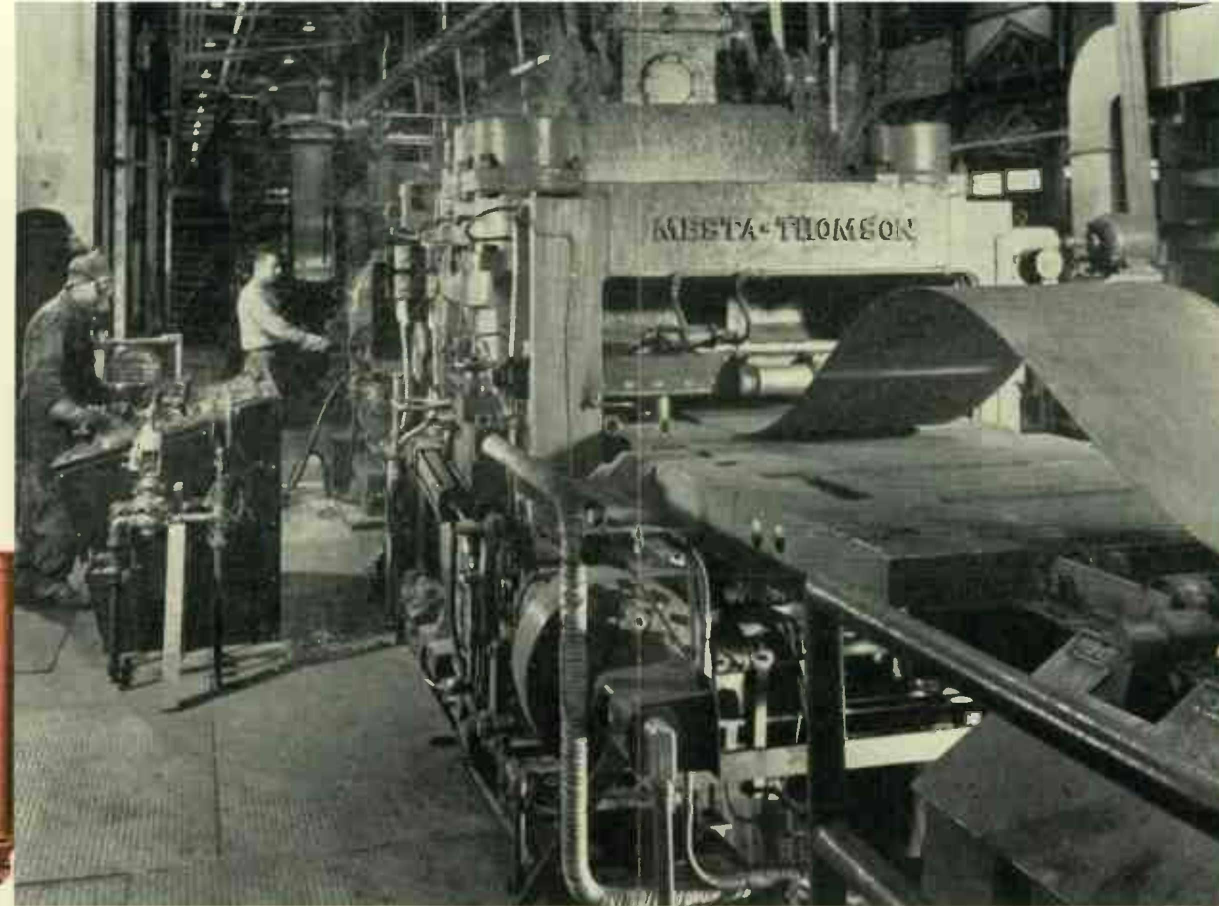
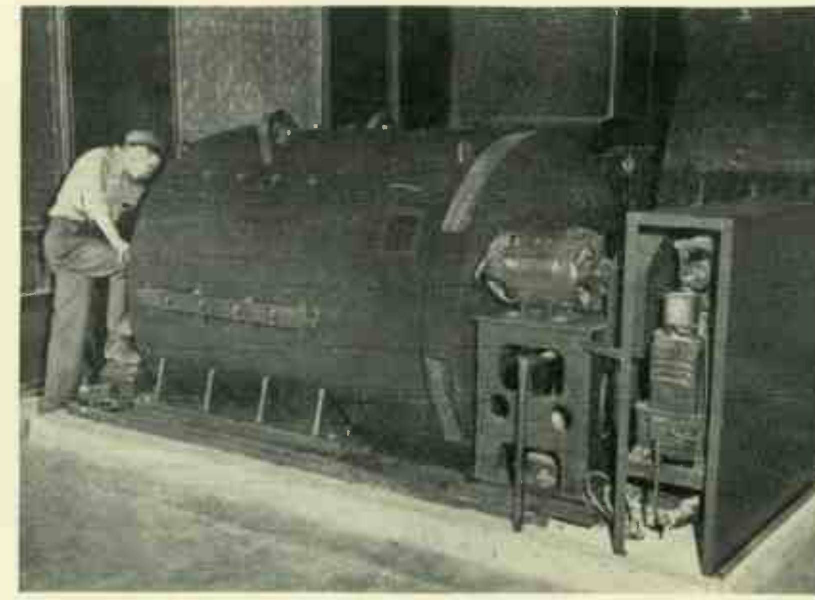
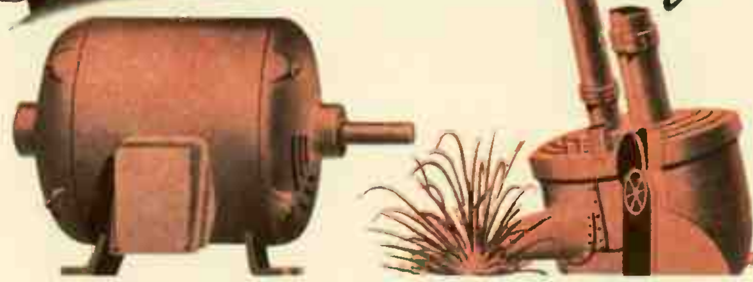






Above—This large motor is the drive for a flying shear beyond the brick wall. *Center*—With an ignitron dealing out correct and exactly repetitive amounts of heat, this flash-welding operation on a high-speed pickle line is enabled to provide consistent welds. *Left*—The direct-drive motors for a high-speed tandem rod mill and, at left of picture, their electronic speed control. A portion of a Rototrol is in the right foreground.

Uses of Electric Power



THE oldest trends in industry are today the most conspicuous. These are the needs for enabling machines to create more goods of better quality and—this is of utmost importance—with less human attention. Never have the forces compelling greater machine productivity been so strong. The results of this are clearly evident throughout the gamut of industry in new drives and new controls being applied. The result has been a great impetus to electronic controls and to rotating regulators and amplifiers of the Rototrol type. In steelmaking particularly Rototrols appear at almost every step in the operation—from controlling the operation of the blast-furnace skip hoist to the maintenance of tension on the finished strip as it is wound on reels. They are now used on blooming mills, for example, to control screw-downs, the front and back tables, feed rolls, and the sideguards and ingot manipulators. Even the runout-table motors in a strip mill of the Bethlehem Steel Corporation are synchronized with the mill stands. Use of a d-c adjustable-voltage system under control of a Rototrol that observes the speed of the last stand makes this possible automatically, and reduces the requirement of frequent hand adjustment.

Better Steel, Faster—A hot-strip pickling line of Jones and Laughlin Steel Corporation runs at a speed of 600 feet per minute—just twice as fast as any other. To determine the capabilities of the line it has been operated in commercial runs at a speed of 775 feet per minute. In a month it can clean the scale from 2000 miles of hot-rolled strip preparatory to cold rolling, and thus integrated with the 6000-foot-per minute strip mill, which, too, has set records for speed.

This represents an interesting coordination of a start-and-stop operation with a continuous one. The sheet must feed through the acid bath as a continuous strip at a closely held constant speed of 600 feet per minute. The strip comes to the pickle section in coils, so that the ends must be welded together to form the continuous strip. The front end must, therefore, run much faster (1400 feet per minute) to accumulate enough strip to allow a stop to be made for the flash weld. A stop for welding must be made every 90 to 120 seconds. This speed and duty cycle precludes the usual motor-operated rheostats for controlling the speed of the pickle-line motors. With Rototrol control, the line can be brought from standstill to 1400 feet per minute in 3½ seconds and stopped by regenerative braking in 2½ seconds.

This same pickle line employs another new feature. Ignitrons, instead of the customary contactors, are used to control the flash-welder current. The ignitrons control not only the number of cycles the weld current is allowed to flow but also the portion of each cycle that is used. Thus they insure that successive welds are identical. Because of the uniformity of welds subsequent breakage at joints as the strip goes through the cold-strip mill is greatly reduced. This means fewer mill shutdowns with their loss of production and possible equipment damage. In some plants the cold-strip mill is purposely slowed down while the joint goes through. This impairs production and affects the quality of the product slightly by the change tension during acceleration and deceleration. Some mills are arranged so that two strands go through the rolls cold-reduction stand at full speed. The ignitrons also eliminate the heavy maintenance required on contact mechanisms.

Mills that roll heavy rod down to pencil diameters usually consist of a succession of stands only a few feet apart. Some mills are arranged so that two strands go through the rolls at the same time, side by side. Thus at any one instant a particular stand in the group may have one half load, full load, or none at all. This means sudden and large load changes. Even with the shock of a rod suddenly leaving or entering a roll the speed must not change as the distance between rolls is often so short that neither slack nor stretching of rod can be tolerated. The high speeds of modern rod mills, such as at the Laclede Steel Company, Alton, Ill., and the Rustless Iron and Steel Company, Baltimore, Md., call for something special in the way of drives and controls. Adjustable-voltage motors with extra inertia and with electronic regulators have been applied. The shock loads are now taken at high speed without noticeable effect.

Electronic controls are generally accepted as the ultimate in speed of action and fineness of control, and are becoming a greater necessity as machines are pushed to higher outputs. But it is commonly believed these qualities are achieved at an increase in complexity. This is not always true. A vastly improved drive on a flying shear in the 68-inch Sparrows Point hot mill of the Bethlehem Steel Company has an electronic control housed in metal cabinets less than three feet total width, whereas previous magnetic controls occupied ten feet.

Flying shears must, obviously, be synchronized with the last pair of rolls in order to cut the fast-moving strip into the desired lengths. This has generally been done by a hydraulic linkage with a multiplicity of pipes, valves, and connections, controlling two high-speed motors geared to the revolving knife. These geared motors have had to be placed in the cramped and very dirty, wet quarters adjacent to the knife itself. An electronic regulator closely similar to that developed for paper-machine drives now gives the speed control, replacing the hydraulic system. A single direct-drive motor capable of developing extremely high peak torques now drives the shear. Because the drive is direct the motor has been taken from the undesirable mill location and placed in the clean air of the motor room, driving by a long shaft through the wall. Because of the high torque available and precise speed control possible with the electronic system the shear can be stopped after making the cuts in one strip length instead of being allowed to run continuously. This means that the first cut is always made in the right place, whereas before up to 95 percent of the first length was wasted as scrap. In addition to increasing production and providing more accurate cutting of strip because of the combined Rototrol and electronic control, the new shear drive and control require much less attention by the strip-mill operators and need less maintenance.

A photoelectric scanner for coil diameter compensation has been put into service on a number of single-stand reversible cold-mill reel drives. Here the unwinding reel must run slower than the mill and winding reel because of the reduction of the metal. Arrangement of the control to obtain automatic "draft" compensation has been a difficult problem. In the past, most drives have been provided with manual "draft" compensation and with additional range of control to allow for unavoidable error by the operators. The scanner, operated with Rototrol control of reel-motor armature voltage, provides a simple method of automatic draft compensation and of automatic maintenance of tension without interruption during reversal. Constant tension is maintained on both sides of the mill at any speed and draft. Nothing touches the metal except a light beam, which is automatically positioned to be tangent to the coil. The motor field strength is changed as the photoelectric device moves so that it is proportional to light position and thus to coil diameter.

New Controls Aid Paper Making—Electronic speed regulators have practically swept the field on machines equipped with sectional drive. They have brougnt a new

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to variations in dyeing the yarn. An electronic regulator was specially built to provide this unusual sensitivity.

The tendency to provide a generator for each motor on a sectional paper-machine drive or a steel-strip mill is to be noted. With mill speeds and capacities increasing, motor sizes have increased to the point that one generator per motor is justified. An individual generator for each motor provides several advantages. Wide speed ranges are possible because armature voltage as well as field voltage can be individually controlled. It provides quick response for high inertia loads, as well as some actual simplification of control panels.

The Lifeline Motor Diversifies— As the end of the war neared, Westinghouse motor authorities elected to establish a wholly new motor in which could be incorporated the lessons learned during the war and the immediate prewar years, and to plan and tool for its construction on a high-volume basis that a reconverting industry was expected to require. It resulted in the now well-known Lifeline motor of all-steel construction, pre-lubricated sealed ball bearings, and smooth eye-appealing contours. The foundation for this family of motors was the general-purpose, polyphase, squirrel-cage motor of 1 to 15 hp (four-pole basis), of which over 300 000 have been built. The time required to tool and prepare for production an entirely new line of motors entailed painful delays at a time when motors were needed badly. However, this program is now paying off handsomely in advantages both in quantity and quality that are carried over to less common varieties.

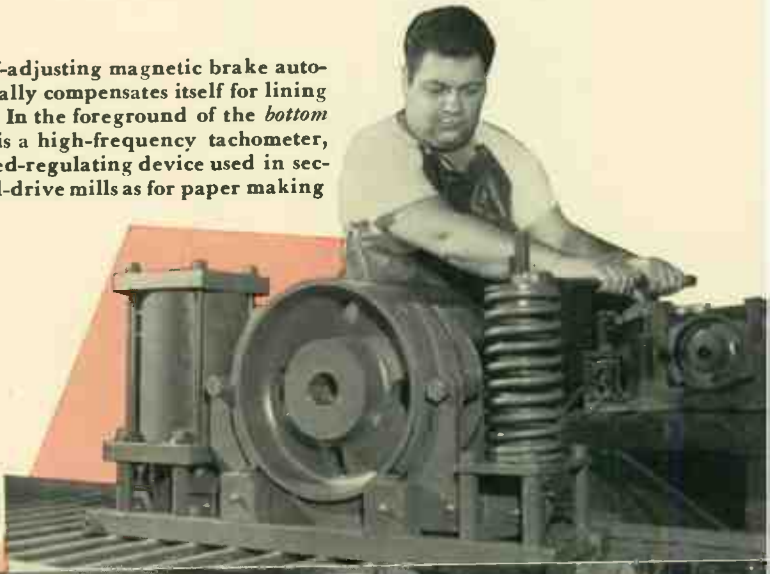
First to be modified for large volume were the single-phase motors, of which almost 30 000 were built in the first six months of 1948. This motor has rather remarkable electrical characteristics; for example, its starting performance enables it to replace the more complicated and expensive repulsion motor. It is made possible because it can employ many of the tools and construction techniques justified by the much higher volume polyphase motor.

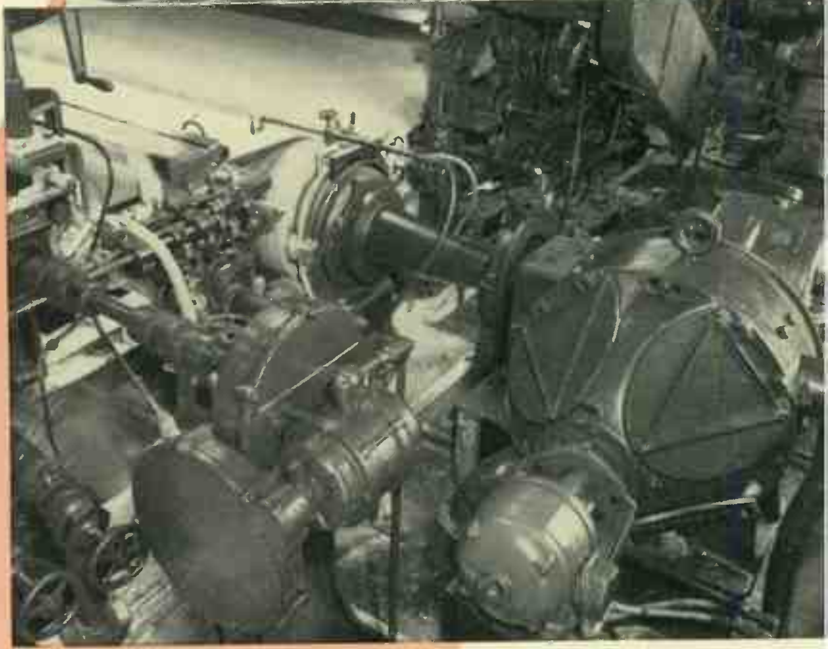
Many other extensions and variants of the polyphase Lifeline motor are beginning to appear. One logical growth is to larger sizes. The family up through the 75-hp, 1800-rpm size (NEMA frame 445) is in production. Experimental models—still months away from the production line—have been built up to 700 hp, 3600 rpm. While they definitely employ Lifeline principles and practices, these larger sizes cannot be simply larger editions. As the horsepower rating of a motor is increased, the motor surface, or heat-radiating ability, does not increase in like amount. Cooling becomes increasingly difficult. A big help has been the development of a new, much more efficient blower. Instead of the simple "paddle wheel," a new cast blower was developed utilizing the experience obtained in building motors of several thousand horsepower. While the end brackets of the larger motors cannot be of pressed steel (because such heavy pressings are mechanically impractical) the stator-supporting frames are of steel; the electrical-steel core is all welded and with its winding is a self-sustaining structure that can be pressed into the frame as with the base members of the line.

The Lifeline series now includes wound-rotor motors up to 15 hp. Unlike older types these employ stators virtually identical to those of their squirrel-cage cousin—a great economy in manufacturing time. Although, on the average, the new wound-rotor motors are 15 percent smaller for the same horsepower, more room is allowed for brushes and rigging, covers are simplified, and access to the current-collector mechanism is increased.

Not a man from Mars, but one clad in asbestos as he photographs flame propagation, in developing explosion-proof aircraft motors.

A self-adjusting magnetic brake automatically compensates itself for lining wear. In the foreground of the *bottom view* is a high-frequency tachometer, a speed-regulating device used in sectional-drive mills as for paper making





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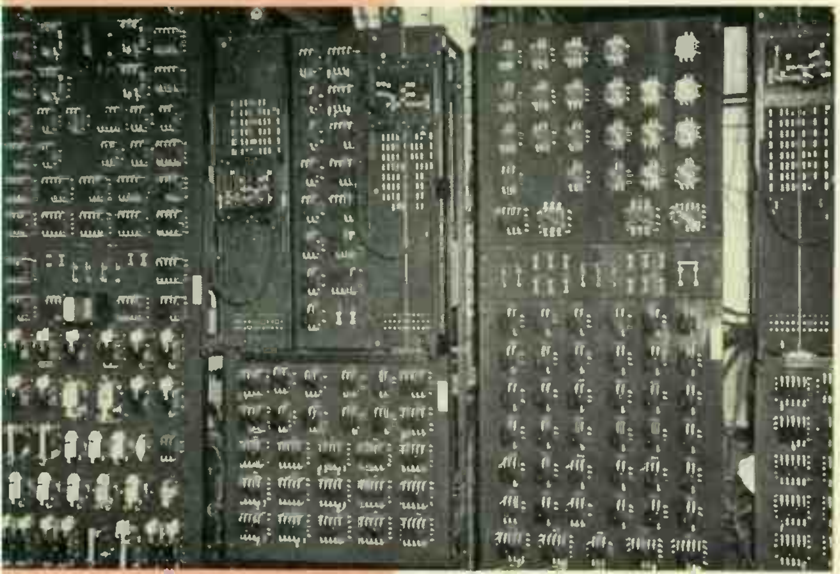

When one rides an automatic elevator, batteries of relays and switches like this go into action. Here controls for a four-car bank of automatic elevators are set up for complete coordination test.

Alternating-current welding is rapidly rising in favor. This unit has a maximum open-circuit voltage, in the interest of operator safety, in addition to features of flexibility and ease of adjustment.

Pumped ignitrons have taken the step to higher voltage. This 3000-kw, 3000-volt rectifier is supplying power to mining locomotives in Utah. The rectifier, with special grid and extra heavy construction, has been able to operate very successfully at this high voltage even with the sudden, large load swings of mining service.

Variations for special needs are easy to create, which helps to keep cost down and to improve availability. Motors of special requirements can be had—such as for high starting torque or multiple speed. To create a motor that appeals to the food industry, where ability to keep the motor clean is important, basically all that was necessary in the totally enclosed non-ventilated type was to leave off the standard pressed feet and weld longer angle-iron feet, add a new conduit box, and raise its mounting—thus eliminating pockets inaccessible to water jets from a hose.

Motors with long creepage paths for any internally produced flame, required for explosion-proof service as in mines, have also been added to the Lifeline family. Next addition will be the d-c Lifeline, to be in production this year.

Motors Meet Unusual Demands—One of the fascinating things about motors is the never-ending variety of jobs they are called on to do. Sometimes these unusual requirements can be met by a motor just slightly modified from standard—on other occasions a motor totally unlike anything previously built is a must. Several recent applications illustrate this.

Motors driving centrifugals in sugar-refining plants spend almost all of their time starting and stopping heavy-inertia loads. Two-speed, squirrel-cage induction motors are used, arranged for regenerative braking during deceleration. New motors have been specially designed for this work. Because they must absorb a large amount of heat during a short time, special consideration is given to make sure that no "heat pockets" develop, and that the heat is distributed well throughout the machine. As an extra precaution glass insulation is used in winding the stator. Extra dips and bakes in insulating varnish are provided to protect against moisture and sugar vapors thrown off from the spinning charge. Squirrel-cage windings are provided with uncommonly high heat-storage capacity. The design is such that at the change-over from high to low speed the transient torque is minimized, thereby reducing shock to the mechanical parts of the centrifugal.

On the ventilating fans for the new Battery-to-Brooklyn tunnel, new types of motors are required. To meet the change in ventilation load from afternoon rush hour to the wee hours, three fan speeds are necessary. These are provided by two induction motors, one of which always runs idle, permanently connected to the fan by chains. One is a large single-speed motor for maximum speed, the other a much smaller motor with two different pole combinations to obtain two speeds. All are fan cooled, totally enclosed, and employ spherical roller bearings. Special snow shields for the conduit boxes are required to prevent snow from being drawn in with the fresh air and swept up into the motor windings. The small motor had to be designed to start the fan and the large high-speed motor, even in the sub-zero weather sometimes encountered in New York. Because the fans operate for long periods at light load (average yearly operation, 5000 hours at light load, 350 hours at intermediate load, and 22 hours at full load), efficiencies, particularly of the small motor when running at lowest speed, are important. This motor, as a consequence, has better than average efficiency at low speed, when driving the blower and the large idle motor.

New motors have been created for flood-control stations. Here the emphasis is on ability to start and carry full load quickly after long shutdowns, and on moisture-resistant insulation. Fibrous or hygroscopic insulation (including asbestos) cannot be used. Extra coats of Thermoset varnish (as used on naval ordnance) are used on insulation and metal parts.

High-voltage distribution networks are not always available where large motors are to be used. In such cases it is

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sometimes necessary to raise the motor current to extremely high levels. A good example of this situation is the 1250-hp, 208-volt, 300-rpm synchronous motor recently built for a New York gas company. Full-load current is 2700 amperes. It has the largest horsepower rating at this voltage of any synchronous motor built by Westinghouse. It has only two turns per coil and is fed by 24 cables (eight per phase).

Bigger, Faster Motors for Testing Bigger, Faster Jets— The urge to get there faster inevitably calls for more powerful engines—a trend that is reflected in a need for more powerful testing equipment. To supply air for testing ram-jet engines, engineers last year undertook construction of a 10 000-hp, 3600-rpm motor, to be the largest of that speed. Now in the process of design and construction is a still bigger 3600-rpm motor, rated at 15 000 hp.

The new motor will be used for testing components of jet engines. To test compressors it will be used as a motor, and to test gas turbines it will run as a loading generator. When operating as a motor or a generator, it will draw or deliver power through an existing 120-cycle adjustable-frequency power supply. By virtue of its adjustable speed and the addition of a speed-increaser gear unit, it will be capable of testing units rated up to 15 000 hp and 17 500 rpm.

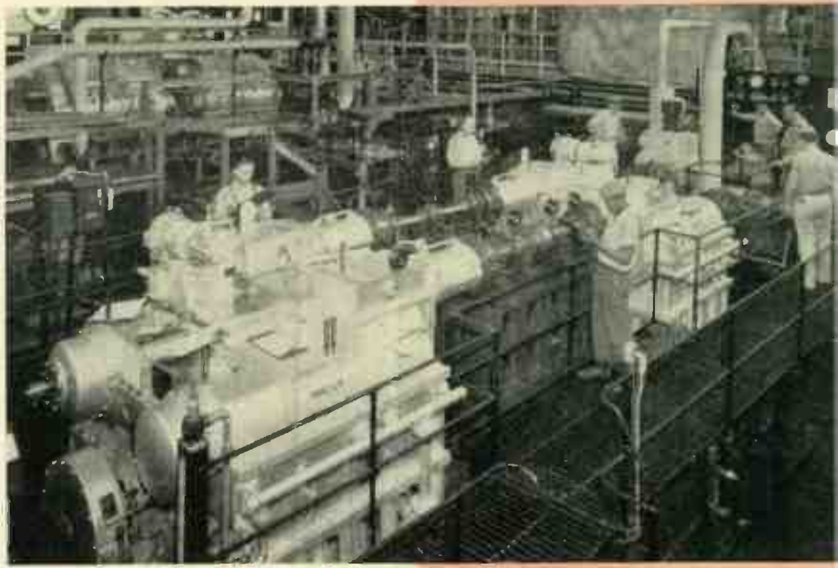
The motor, a 120-cycle, 4-pole machine, will be started at low frequency (approximately 30 cycles) and accelerated to whatever speed necessary by raising the frequency. A double shaft extension will permit the motor to be coupled to more than one unit should the need arise. Cooling air for the motor will be supplied by a separate motor-driven blower. Such a ventilating system is necessary because the usual motor-shaft-mounted blower would be unable to supply sufficient air when the motor is operating at low speed. Aside from this feature, the machine's construction will be similar to that of a standard steam-turbine-driven, 10 000-kw, 3600-rpm generator used in industrial power plants.

Simpler Starting of Synchronous Motors— Starting a synchronous motor requires a decision. Somebody—or better, some thing—must decide when is the proper time to apply the direct-current field, thereby synchronizing the motor with the line. Generally a set of relays and switches designed specially for this function is used.

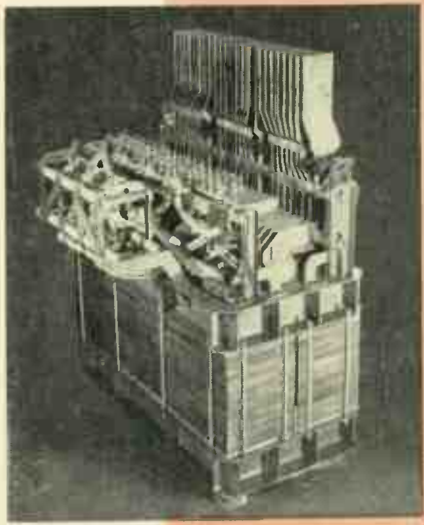
A new relay (ASR) is simple. Exercises better judgment too. This remarkable relay has a time "yardstick." When the motor is started the relay keeps comparing its time yardstick to the length of a-c half cycles induced in the unenergized field. As motor speed increases, the frequency of this induced voltage diminishes, since rotor speed gradually approaches synchronous speed. The relay, in effect, watches until the time for one-half cycle becomes just as long as its "yardstick." Then it signals the field circuit to close.

Synchronizing this way achieves, automatically, something else that previously required special equipment—angle switching. The relay automatically selects the time for synchronizing when the rotor and stator poles are in the most favorable position (relative to each other) for least mechanical shock when the d-c field is applied. This also provides maximum pull-in torque with least current surge from the power line.

New Brake Automatically Adjusts for Wear— When the shoes of a drum-type friction brake release they should retract from the drum just far enough not to drag. If they move away too far, resetting of the brake results in shock and chatter. But since both brake shoes and the bands wear, the clearance on the conventional fixed-setting brake continually gets larger. This calls for readjustment. Frequently access to brakes



By loading these two sets of marine gears against each other in a test to destruction a standard gear proved its ability to carry up to three and one-half times its rated full load. (Photo by U.S. Navy)



This transformer with outsize conductors is to serve an electric furnace. The old problem of sealing and insulating the conductors has been solved with synthetic rubber boots that also lend flexibility.

These double-deck, multiple-unit cars are now in rapid-transit service on the Long Island Railroad. Each is powered by two 230-hp, 650-volt motors, has a top speed of 77 mph, and can seat 134 passengers. These cars can be used singly, in trains with similar cars, or in trains with non-powered cars in a ratio of six to four.

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and their servicing is genuinely difficult—as on the top of cranes. Also the adjustment necessary is difficult to judge.

A new and still experimental magnetic brake is self-adjusting. Once set it need never be touched until the bands wear out, since it adjusts itself automatically after each operation. The magnet is connected to the shoe rigging by a tapered-clutch arrangement that, when the magnet is energized (to release the brake), allows the spring to pull the shoes back a measured distance from the drum—thus automatically compensating for wear.

Gears Carry Triple Load— The short-time overload ability of some kinds of machines can be readily ascertained. But with others such allowable loadings are all but impossible to determine. Gears are in this second class. But, recently the Navy did test this ability. Two sets of standard 6000-hp gears made for naval escort vessels were available as surplus from war stock. They were identical except for the different tooth-cutting methods used by the two manufacturers. One of the gear units was built by Westinghouse to the same standard as the larger gears for the biggest fighting ships. These two sets of gears were mounted by the Navy in the Naval Boiler and Turbine Laboratory in Philadelphia in a "front-to-front" arrangement (similar to electrical "pump back" tests) so that one set loaded the other, and driven at normal, rated full speed. Tests of 100-hour duration were run, the loading being increased for successive tests. The loads climbed to 150 percent, to 200, 250, 300. Still the gears continued to perform satisfactorily although pitting of tooth surfaces developed. It was not until they had been loaded to 340 percent of normal that teeth on the bull gear failed. It had operated almost 3000 hours at loads up to nearly 3½ times normal. Even at this point the first reduction gears and pinions showed no signs of tooth distress and were capable of carrying full load indefinitely. No journal bearing failures developed during this extreme test. These tests indicated that the smoother tooth surface as provided by lapping or shaving has a considerable value in increasing the resistance to pitting, but little effect on the ultimate ability of the gear to carry load. The tests also proved that a long run-in period of operation at light load to gain a work hardening of the teeth surfaces is not necessary to achieve high load-carrying ability.

Such data will enable gear engineers to design gears more rationally for service requiring short intervals of extreme overloads, as occur in naval service, but seldom occur in other marine or industrial applications.

Generators without Brushes— Ever since airplanes have been flying at high altitudes engineers have had a problem on their hands with generator brushes. Brushes that lasted almost indefinitely at sea level lasted perhaps two hours at 30 000 feet. In time, halide-impregnated brushes were developed, which greatly eased the problem for such altitudes.

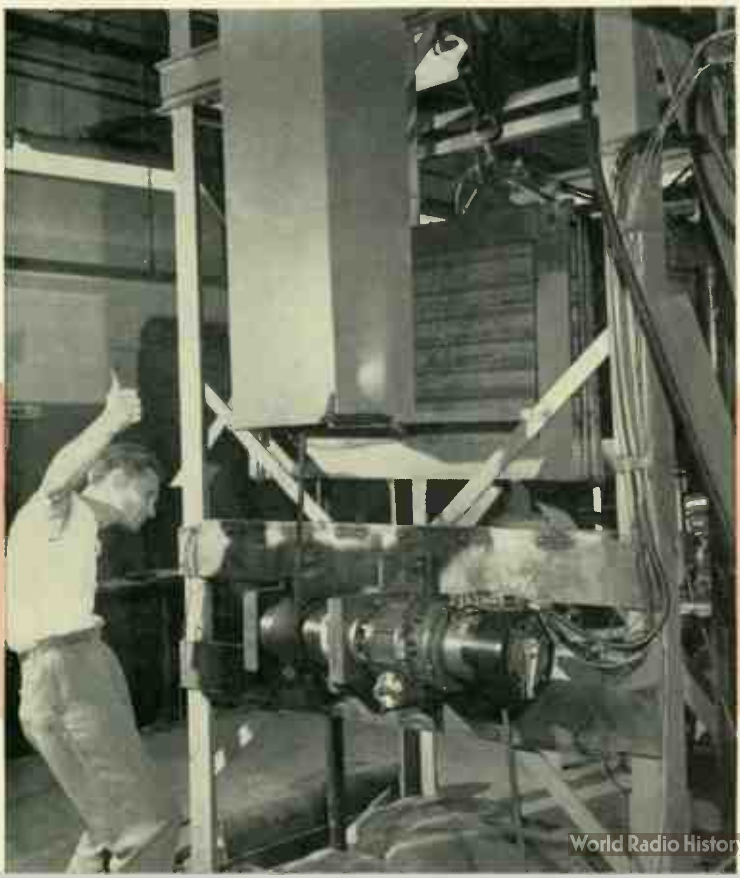
But airplane men would like to eliminate as many brushes as possible, especially in jet aircraft, which are pushing ceilings up still higher. Toward this end a brushless a-c generator has been developed.

The generator is a three-phase machine, rated 400 volt-amperes continuously at 120/208 volts. Its frequency output is 300 to 800 cycles, corresponding to its expected speed range of 4500 to 12 000 rpm. It employs the old inductor principle. The stator has two windings, one to furnish d-c excitation and the other to provide the a-c output. The rotor is a solid piece of steel having eight pole faces but without windings. The changing magnetic reluctance as the rotor poles sweep past the stator creates the varying flux change that induces an alternating voltage in the stator output winding. The generator will be used in the control system of jet engines and will operate at any altitude.

Keeping the Fireworks Inside— A mixture of gasoline vapor and air in a ratio as small as two parts in a hundred has by weight many times more explosive energy than dynamite. Therefore it is essential to confine any flame due to an explosion inside airborne motors, so that the larger volume of vapor outside will not be ignited. Obviously, the heavy totally enclosed construction with wide fits and long labyrinth seals, used to make industrial equipment explosion-proof must be avoided because of weight. Other means as effective, but lighter, have been devised.

An aluminum or copper mesh, called a flame arrester, is placed in special ventilating ducts in the motor. It does not reduce the flow of air to any extent. When an explosion occurs inside, the gas escapes through these openings, this being the path of least resistance. The hot gases and flame strike the mesh, which reduces the temperature below the danger point. The result is a ventilated, explosion-proof motor.

To Keep Voltage Flying Right— Airborne electrical equipments are just as fussy about their operating voltage as are their earth-bound industrial counterparts. Should voltage fall too far below rated, for example,



Indicative that commercial air freight has passed the stage of cut flowers, film, and jewelry is the fact that airplanes now have powerful cargo hoists. A new type of hoist is being built for the latest large cargo planes. It is rated 15 000 pound-inches at 12 rpm (4.2-hp motor rating), which means that it can lift a 1-ton load at almost 50 feet per minute. The cargo hoist consists of a 26-volt, d-c motor (with flame arresters for explosion proofing), a magnet brake, a friction-type overspeed device, a torque-limiting clutch, a gear train, and a worm and wheel for manual operation if necessary.

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motors will not deliver their full output and relays will not function properly. Electronic devices and lamps are even more sensitive and are adversely affected by either excessively high or low voltage.

To keep aircraft-generator voltage close to normal a carbon-pile regulator is used. The regulator, which consists of a stack of carbon disks whose electrical resistance varies inversely (although not proportionately) as the pressure applied, is inserted in the field circuit of the generator. The pressure is determined by a magnet energized by the generator bus voltage. While accurate voltage regulation under all conditions of engine speed and generator load is the first requirement of the carbon-pile regulator, the device must have other characteristics, among which are light weight, resistance to ice, water, salt spray, and sand, and consistent performance and long life in spite of changing altitudes, ambient temperatures, vibration, and acceleration.

During the war thousands of similar voltage regulators were built with a resistor-stack dissipating rating of 75 watts. These were principally for the armed forces. Although they performed satisfactorily for a limited time, the armed forces, aircraft builders and users indicated their desire for a unit of higher rating, little added weight, generally improved performance, longer life, and requiring less maintenance.

A new carbon-pile regulator rated 90 watts of stack dissipation for 28-volt generator service fills the bill. It weighs but 44 ounces, only 3 more than the 75-watt device, an increase of 7.3 percent. Although the entire movement of the solenoid armature is but 0.006 inch, the resistance changes from 1¼ to 35 ohms. Essentially, its principle of operation is similar to that of the old regulator but it has several unique features that result in better overall operation. It employs a thin, soft copper diaphragm to form a tiny air chamber 8 to 10 thousandths inch in depth by 1¼ inches in diameter to provide a damping action to changes in voltage setting. The spring action of the diaphragm and movement of air in and out of the chamber perform the damping and prevent fluttering and instability. It also reduces wear of the carbon disks. The disks are enclosed in an accurately ground Pyrex-glass cylinder that resists heat shocks due to rapid temperature changes. The Pyrex is enclosed in an Invar structural member, onto which are cast aluminum fins that conduct heat away from the regulator and keep the carbon stack within reasonable temperature limits.

Modifications of this same regulator can be used for 120-volt a-c and d-c aircraft generator service.

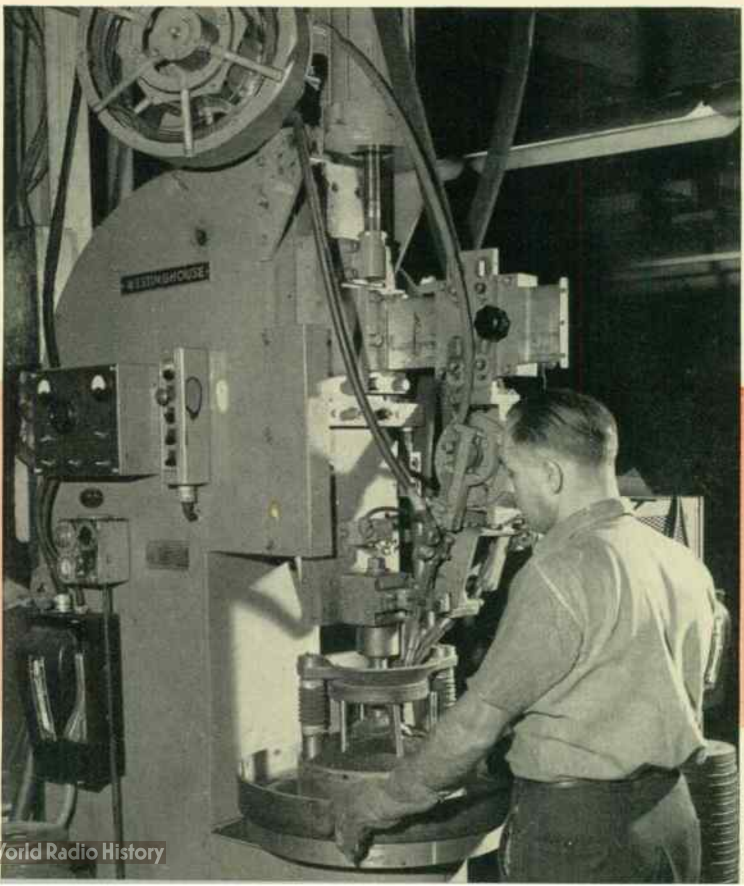
Atoms to Take a Beating— In the pell-mell race to build the first atomic bomb scientists attacked their problems with only one thought in mind—build a workable, effective bomb, and quickly! Hundreds of facets of the problem had to be by-passed because they had no direct bearing on the immediate problem. Study of other uses for atomic energy was temporarily shelved. Now scientists are returning to basic research and discovering why some of the things they tried worked, and exploring many of those side issues.

The major tool in atomic research is undoubtedly the atom smasher—the "Big Bertha" of the scientist. Of the numerous forms that atom smashers take, perhaps the most famous, and deservedly so, has been the cyclotron. But like all machines it has its limitations. It operates on the principle that a charged particle in a plane perpendicular to a uniform magnetic field moves at a constant angular rate, regardless of the speed to which it is accelerated. Propelling voltages can be increased to a point, thus raising the velocity of the particles. But as velocity nears the speed of light a mass change takes place in the particle and it no longer performs according to this pattern. These mass changes can be offset either by adjusting the timing or phase of the a-c "kicker" voltage, or by varying the field intensity of the magnet, but changing either of these conditions necessitates a new design.

The trend is toward achieving higher velocities by adjusting the field intensity. Evidence of this is to be found in two new particle accelerators of astonishing proportions. One is now in design stages at the Brookhaven National Laboratory in New York; the other is being planned at the University of California at Berkeley.

The Brookhaven installation, which is to be called a cosmotron, will produce about 3 billion electron volts energy and will be used to accelerate protons to 97 percent the speed of light. At this speed, approximately 180 000 miles per second, a proton will have about four times the mass it has at rest.

Essentially, the heart of the cosmotron is the circular magnet that supplies the magnetic field, and its electrical supply. The magnet itself will be divided into four quadrant sections, each of which will be wound with 48 turns of water-cooled busbars. Supplying the energy to hold the protons in this circular path as they are given successive kicks by a small oscillator will be an a-c generator, which will feed d-c power to the



Automatic welding can now be purchased as a single coordinated package. Heretofore a welding head, transformer (for alternating current) or motor-generator set (for direct current), control, table for holding the work, and wire and flux—had to be assembled from separate suppliers. The set is completely automatic. An operator pushes a button, the machine takes over. The welding head lowers into position, flow of flux begins, the arc starts, the weld is made, the table stops, the head retracts upward, and the machine waits for the next load.

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magnet by means of a 4260-volt (peak), 7000-ampere ignitron rectifier. To bring the generator up to speed and to supply the losses of the system, an induction motor will be used.

To hold the heavy protons in the circular path a d-c field is needed that builds up to a maximum in one second and goes to zero in 1½ seconds with 12 pulses per minute. Pulses of this magnitude, about 26 000 kw, are a terrific drain on an electrical system, and necessitate a huge flywheel on the generator shaft to store energy and return it to the magnet supply during build-up of the cycle. Protons accelerated by the oscillator voltage and held in a circular path until they maintain maximum speed are then deflected to bombard a target.

Even as the Brookhaven smasher is being planned another and larger synchro-cyclotron is in the development stage. This gigantic smasher, at the University of California, will produce about six billion electron volts, twice as much as the Brookhaven installation, and will be over 17 times as big as the present Berkeley cyclotron—which is the largest in the world today. It will be known as a "bevatron" (for billion electron volts). The magnet for this giant will be 110 feet in diameter and will be supplied by two a-c generators (through ignitrons) with a peak power output rating of 100 000 kw. Each of these will feed power to the magnet through four 3000-volt ignitron rectifiers in series. The voltage level will be maintained during pulses by two 85-ton flywheels.

The huge power demands on the generator necessitate the use of 40 percent more copper than on a standard machine of the same rating. The generators must also be extremely well braced mechanically since they are subject to heavy magnetic stresses under fault conditions, due to the tremendous currents involved. The pumped ignitrons used in this installation are of the highest voltage rating made. The steel flywheels will each store about 300 000 kilowatt-seconds of energy and give up about 40 000 each cycle to the magnet, thus avoiding disturbing loads on the outside power system.

These two new atom smashers should provide much valuable information in the realm of atomic physics—a realm of which little is actually known today. They can be used to create mesons, the mysterious particles that still keep many secrets hidden from us, and to study the forces that hold the atom together. These are but a few of the uses to which atom smashers of this magnitude can be put; subsequent investigations will undoubtedly reveal many more.

Arc-Welding Equipments— The most significant trend in arc welding is the relative growth in usage of a-c equipments, as indicated by the industry-wide increase in percentage of total purchases from 13 to 23 percent—or nearly double—in less than eight years. The advantages of a-c welding—absence of arc blow, elimination of rotating power supplies, and reduced power and maintenance costs—are the prime causes.

A new family of a-c welders, having an open-circuit voltage of only 65 volts, is helping to further the trend to alternating current. The welders are built in five ratings from 200 to 600 amperes. They employ a capacitor-resistor arc-stabilizer circuit that provides improved arc-striking characteristics and arc stability with any type of a-c electrode at open-circuit voltages as low as 55, which may exist if line voltage drops.

Accurate current settings are made conveniently by an adjusting handle and a uniformly calibrated current-indicating dial mounted together at the top of the welder. The handle controls a movable iron core that by-passes a certain amount of flux, depending on its position, and consequently changes the circuit reactance. Thus current is changed even under load, without moving any current-carrying parts. Use of grain-oriented Hipersil steel makes possible small lightweight units—only 440 pounds for the 400-ampere portable unit. The primary power factor of these machines is over 80 percent at rated current. Efficiency is better than 90 percent from 20 to 125 percent load.

Better Furnaces for Metallurgical Cuisine— Our grandmothers were cranky about the temperature of the ovens in which they turned out those mouth-watering pastries. However, in comparison with modern metallurgical chefs with their heat-treating furnaces, they were grossly careless. A conspicuous industry trend to greater use of alloys and steady development of new ones has led to insistence on electric- and gas-fired furnaces with more precise temperature distribution and control. Furthermore, metallurgists are continually increasing the strictness of their requirements for composition control of the atmospheres that surround their "bakes."

Several recent installations illustrate the continuing refinement and greater versatility industrial-heating engineers have applied to controlled-atmosphere furnaces. A manufacturer of hand tools—pliers, wrenches, screw drivers, etc.—wished to apply the technique of Austempering to his product to achieve a superior degree of hardness and toughness. Instead of quenching quickly, as is normal practice, the temperature of the heat-treated tools was to be lowered at a closely controlled rate in the salt bath. This involved combining a controlled-atmosphere electric furnace with a special adjustable-temperature salt-bath quench. The matter of building a salt-bath quench into the furnace imposed new problems of protecting the mechanical and electrical parts from the quench fumes and from the effect of the salts—as well as new temperature control and cycling problems.

Ordinarily a furnace is provided with a single type of oxygen-free atmosphere, albeit its composition is controllable within a limited range. Exogas and Endogas, for example, are two different types of gases, both made from natural or manufactured fuel gas and air. Exogas is made by burning fuel gas with fairly large amounts of air, resulting in a gas rich in carbon dioxide and water vapor, and relatively low in hydrogen and carbon monoxide. If the amount of air is limited to a smaller value, external heat must be applied to react the gas and the result is Endogas. This atmosphere is high in hydrogen and carbon monoxide and low in carbon dioxide and water vapor. One manufacturer of alloy and silicon steels wanted the metallurgical versatility that comes from having both gases available. This meant devising a combination Endogas-Exogas generator in a single unit, i.e., one in which a mixture of fuel gas and air, precisely controlled as to ratio, can be combusted to any desired degree. This involved a new kind of reaction chamber in which heat could either be removed when making Exogas, or added in the case of Endogas. One of the advantages of using this generator is that different atmospheres can be obtained at various parts of the cycle without using more than one piece of equipment—gas composition anywhere between the Exogas and Endogas ranges can be readily obtained.

Furnace Transformers Find a Friend in Synthetic Rubber—When someone dreams up a service more difficult for transformers than that found in electric arc-furnace duty, transformer designers won't want to know about it. Furnace-room air is of necessity laden with clouds of electrically conductive dusts. Periods of shutdown are followed by sudden demands for long peak-load outputs. Production schedules usually interfere with maintenance. One particularly troublesome problem has been to seal the transformer against "breathing" of moisture and dirt-laden air. The furnace trans-

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former's heavy current leads cannot be rigidly sealed, say, with insulating porcelain, as in most transformers. With currents varying from zero to many thousands of amperes and conductors so large that several feet of seals per conductor are required, flexibility is essential. An air-tight, electrically insulating, flexible seal has been made possible by utilizing synthetic rubber and a new technique for bonding it to copper on one side and steel on the other. Unlike natural rubber, the synthetic is unaffected by oil vapors.

Last year an unusually large furnace transformer with several new features was built for 25 000 kva with only 35-degrees-C rise; the rating would be much higher with the standard 55 degrees rise. This transformer, installed in a plant of the Northwestern Steel Company, is forced-oil water cooled, has a motor-operated tap changer, and is for the uncommonly high furnace potential of 400 volts. (This means currents of 35 000 amperes per terminal.) It suggests a trend to higher capacity, higher voltage arc furnaces.

Testing at Nearly Twice the Speed of Sound—The drive to obtain basic data on devices moving through air faster than sound is being pushed with vigor. NACA has a flexible and immense new tool for this purpose—a supersonic wind tunnel with a test section of adjustable size—at Moffett Field, California. Behavior of models or some full-scale components can be observed and measured at air velocities up to a Mach number of about two, or equivalent to about 1500 mph at sea level.

This super-hurricane is obtained by two 25 000-hp wound-rotor motors in tandem driving an enormous axial-flow compressor, by all odds the largest ever built by Westinghouse and perhaps the largest in the world. This compressor has eight stages, with rotating blades about two feet long on a 12-foot diameter rotor. Some of the models under test will be "live," having propellers rotating at high speed. Adjustable high-frequency power supply to the models consists of two special 750-kw, 800-cycle motor-generator sets. Because the tunnel is a closed circuit, the 50 000 hp put into the air by the compressor must be removed. To dispose of this tremendous amount of heat a large air-to-water heat exchanger in the tunnel cools the air. A large cooling tower dissipates the heat.

Passenger Cars Go A-C—The electrical loads of railroad passenger cars are outstripping the conventional d-c axle-generator, storage-battery, power-supply system. The need for new types of power plants is indicated.

The electrical power plants for cars have grown from the 16-cell, 400-ampere-hour, 32-volt batteries and 2-kw, axle-driven generators of three decades ago to sizable equipment consisting of 57-cell, 110-volt, 700-ampere-hour batteries and 30-kw generators. The batteries alone on each car weigh 10 500 pounds, while the generators on a 15-car train impose a 750-hp drag on the locomotive, or about 15 percent of its total full-load output. A continuation of these trends cannot long be tolerated. And such won't be necessary when a-c power is used.

A self-contained, packaged, engine-drive a-c power plant suspended beneath each car eliminates the axle drag and shrinks the battery to but a few percent of its former size. This power plant consists of a diesel engine—rated at 54 hp, 1800 rpm under the most severe operating temperatures and altitudes encountered in service—driving a 25-kw, 3-phase, 60-cycle, 230-volt generator in an insulated housing. The power unit, weighing 3900 pounds, is mounted in a frame on small wheels so that it can be rolled onto a track built on the underside of the car. Servicing, or even complete replacement of a unit is thereby facilitated. With this kind of power plant the battery need be large enough only to supply emergency

This new automatic machine, with several new technical features, dispenses bottles of cold Coca Cola, and makes change, if necessary. It has high capacity—ten cases—hence the "Empty" sign comes up less frequently to disappoint the thirsty. Rapid cooling is assured by concentrating the greatest cooling effect on the bottles closest to the vending position. This assures a cold drink even at the highest rates of delivery.

The benefits of quantity production are now applied to electric stairways. Formerly they were custom-built, and thus feasible only for large department stores and railroad terminals. A new stairway is made in a smaller, standard size adaptable to most smaller buildings, and with an attendant cost reduction. To permit weight-saving construction the maximum length is held to 23 feet—which is ample for most buildings . . . A single width—32 inches—is available. The demand for the stairway has justified quantity production.

This new welder makes spot welds at 12 cycles instead of the customary 60. Because of the reduced frequency the current during welding rises at a lower rate. Consequently the current density during the early stages of the welding cycle is smaller, which results in less "spitting" and burning and less electrode wear. The electrode retains its shape longer and makes stronger and more uniform spot welds.

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lighting and engine cranking. The battery is kept charged by the engine generator through selenium rectifiers. A train thus equipped can be operated either with all generators in parallel or with each car electrically isolated from the others.

The a-c system for trains offers many signal advantages. Standard 60-cycle, 110-volt electrical devices—fluorescent lamps, water coolers, electric shavers, radios, and other electrical appliances—can be used without auxiliaries or special construction. Brushes and commutators of rotating machines are eliminated and the maintenance of batteries becomes relatively negligible.

Particularly important is the fact that alternating current makes possible hermetically sealed air-conditioning compressors, which d-c motors preclude. For use with the engine-generator power plant, an improved three-unit air-conditioning system has been developed. It too is based on the package idea to meet the needs of railroads for accessibility and easy servicing. The compressor unit, with two 5-hp sealed compressors, and the condenser unit are mounted under the car. These compressors are readily removable. The fan-evaporator unit is mounted overhead in the passenger-car body.

In addition to the economies of maintenance and the advantages of maximum utilization of apparatus, actual weight savings are significant. The power-supply and air-conditioning apparatus for a car total about 21 800 pounds for the usual d-c system but only 10 700 for the a-c. For a 15-car train this means some 72 tons less for the locomotive to haul.

Four Automatic Elevators Operate as a Team—Future load demands for elevator systems in moderate-sized buildings are hard to predict. A new automatic system—which can be used with as many as four cars and which, when the traffic demand is great or requires policing, can be operated with an attendant—helps to provide traffic flexibility and operating economy for the medium-sized building. Previously the largest automatic elevator systems were two-car units. Although this system operated satisfactorily, it could not be used when the traffic demand was such that more than two cars were needed.

The four-car system—known as the Selective Collective Automatic system—operates entirely automatically under control of an automatic dispatcher, and answers all calls without waste of time or car movement. It is so designed that the car closest to a particular call answers it. A car in picking up or discharging passengers automatically reverses at the highest call and answers all corridor calls on the way down. The number of cars in operation simultaneously is a function of the traffic demand; that is, if corridor calls are registered in both directions at the same time that there is traffic from the ground floor, all four cars will be in operation, causing the passengers minimum waiting time. When the traffic is light, only two or three of the four cars are in operation at a given time. During slack periods, when few calls are registered, three cars remain at the terminal while the fourth stands at the point where it answered its last call, becoming a free car. Quick and economical service is further insured by the fact that, if one of the cars stationed at the terminal leaves with a passenger, the free car returns to the terminal and the car in operation takes its place after completing its mission.

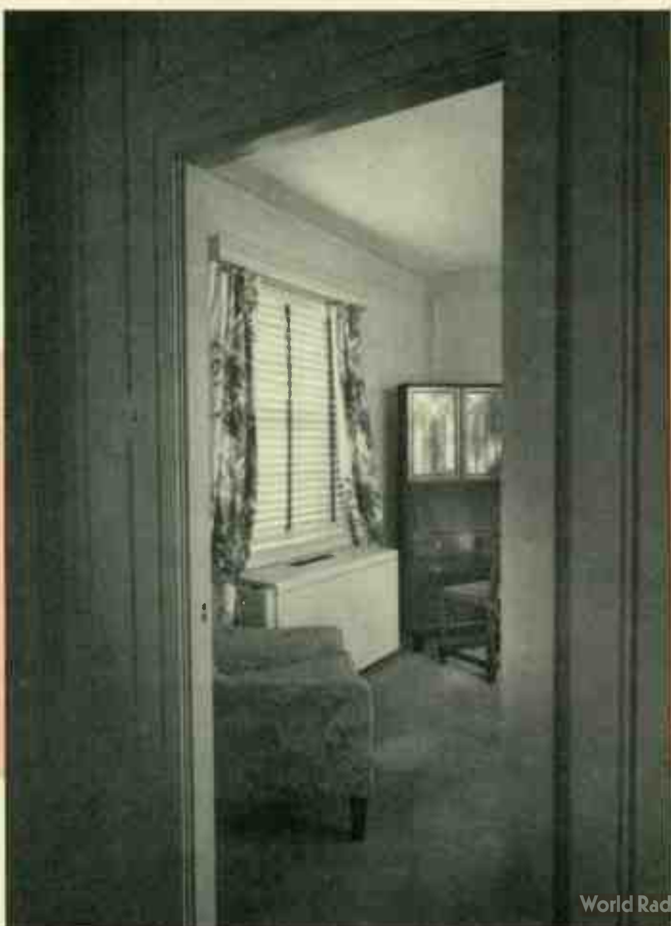
Each of these cars is equipped with an automatic shut-down that disconnects the motor-generator set from the line at a predetermined time after the last call has been answered. The set is automatically restarted when there is again a demand for this car.

The system is so arranged that, if one or more cars are removed from the system for maintenance, repairs or other reason, the remaining cars will operate as a three-, two- or one-car system, depending upon how many remain in operation.

More Brainpower for Elevator Controls— The electrical "brains" of electric elevators, already amazingly talented, now have another factor to consider in making their "judgments"—cable stretch. For all elevators, close leveling at the

With a motor that develops 1/6 hp this food mixer is master of any mixing operation.

This attractive automatic toaster has a silent timer, leaves no pattern of heating wires or untoasted areas on the bread.



← The room conditioner, below the window, cools in summer and heats in winter, obtaining its "cold" and heat from water suitably tempered in a central plant elsewhere in the building. It contains a fan, heat exchanger, and filter.

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floors is desirable. For freight elevators this is particularly necessary since heavy wheeled loads are often moved in and out. In some buildings the cables are long enough to stretch or shorten and let the car drop or rise an inch or two as a heavy truck enters or departs, possibly necessitating a re-leveling. Because the traction motor torque does not build up instantly, when the controller releases the brake to bring the car back into position, the car may actually drop another inch or two or, if the load is light, even rise a like amount.

A new control element, in effect, re-levels the car automatically. A load-weighing device and a control element measures the load in the car and controls the release of the brake. For example, with a very heavy load the control would hold the brake until the elevator motor had built up sufficient torque to relevel the car without further dropping; then it would release the brake and re-level.

The Smaller They Come—Strange as it may seem aircraft contactors find the smaller d-c currents harder to interrupt than the larger. These contactors employ a series coil, through which line current flows, to extend and break the arc, and at low currents the field of this coil is extremely weak. To break an arc, its length must be extended beyond that supportable by line potential. Hence an arc must be extended to approximately the same length whether the current is large or small. Since the amount and rate of extension is dependent upon the strength of the magnetic series field, small currents (which produce a weaker flux) are more difficult to extend to the point of breaking.

Interrupting small currents is particularly difficult at the higher d-c aircraft voltage, 120 volts, for currents are proportionately smaller and the voltage proportionately larger than at 30 volts. The solution is not to increase the number of turns on the series coil as this adds more weight and requires more space. Clearly the need is for a new type of contactor that easily interrupts both large and small currents. And it must be light in weight, low in space consumption, and must operate at any altitude.

A new contactor, which fulfills the requirements, eliminates the series coil and substitutes two permanent magnets. The magnets are of Alnico for high retentivity. The magnets create enough flux to blow out small or large currents. Furthermore, the contactor functions as effectively at high altitudes. Here, arc interruption is more difficult as the same potential can support a longer arc because of the rarified air.

In contactors using series coils the magnetic field reverses with reversal of current. Hence, they need but one arc chute as the direction of arc blow is the same for current flow in either direction. Not so with the permanent-magnet type, however. Therefore, a new, different construction, a two-direction arc chute (one for each direction of current) is employed. The contactor is rated 250 amperes current-carrying capacity at 120 volts direct current, and is capable of interrupting voltages as high as 500 volts, which occur during abnormal conditions.

Room Comfort—Winter and Summer—An improved tool is available in man's enduring campaign for comfort. It is a small, compact, quiet, attractive room air-conditioner that delivers heat in winter or cold in summer. It is a heat-exchanger unit in which hot or cold water is brought to the unit from a central heating or refrigerating system and its effects delivered into the room as filtered warm or cool air. Air is brought in through a ledge underneath the unit by a fan, passed through a mechanical filter, thence forced over the finned-tube heat exchanger and discharged through a grille at the top into the room. As dirt inevitably collects around a return-air grille, possibility of soiling clothing is avoided by the hidden vent. A large-diameter, slow-speed, belt-driven fan insures the silence required for hotels, apartments, and office application. Because the entire side panel, held in place with spring clips, can be almost instantly removed, the ultimate in accessibility is provided. With this system, expensive and space-consuming duct work is eliminated.

Television sets, such as this table model, are becoming simpler and lower in cost.

This coffee maker requires only water, coffee, and a push of a button. It is entirely automatic, even to keeping coffee hot.

The Laundromat and its recent companion, the dryer form a famous home-laundry pair. A new control on the Laundromat permits adjustment of the water level to suit the size of the load, thus effecting large economy in the use of hot water. →

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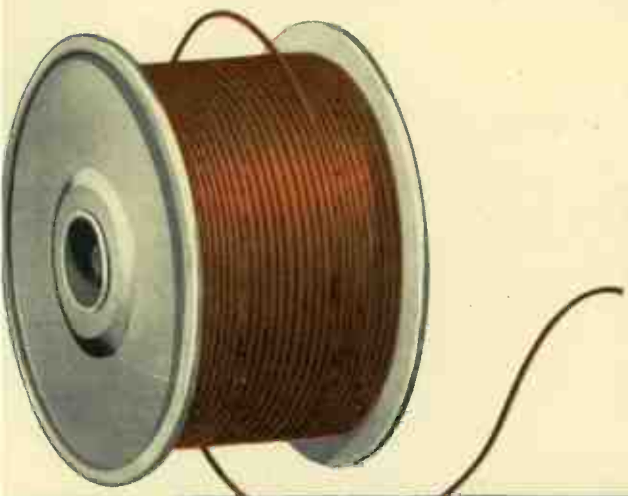
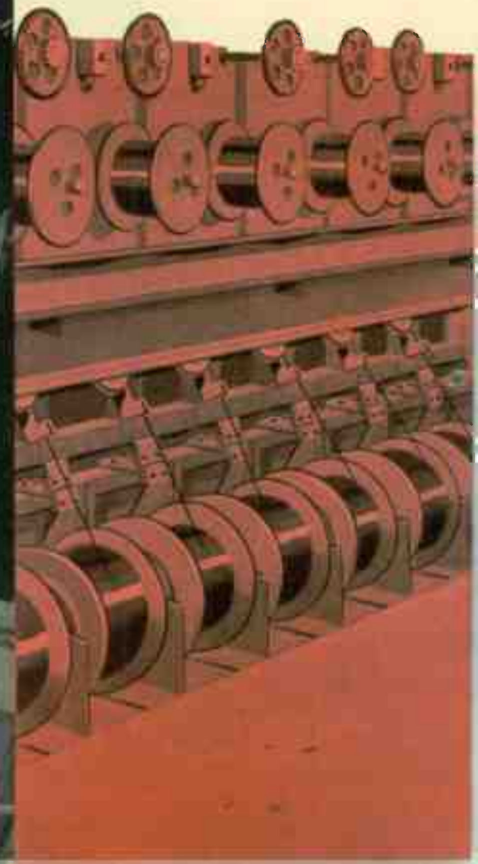


Materials, Processes, and Research

After several years of intensive investigation, research engineers have found a way of amplifying the x-ray fluoroscope pattern by several hundred times. This is the basic step toward solving the fluoroscope's greatest handicap—weak images. This is described on page 30.



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A SCIENTIFIC discovery, a new device, some novel application—these are the things that attract attention, these are the ones engineers like to read about. Less spectacular but no less important in the total are the little-noted improvements in the way machines and devices are made. And these occur by the thousands—better construction methods, new fabricating techniques, improved materials and tools. In fact while less heralded, and frequently not apparent to the user of the product, it is here that engineers have achieved most, especially in the endless struggle to counteract the strong price-increasing factors. Little by little improvements are achieved that integrate to improve today's device or reduce its cost (or both). Examples can be cited by the magazine-full. We'll pick a few representative ones at random.

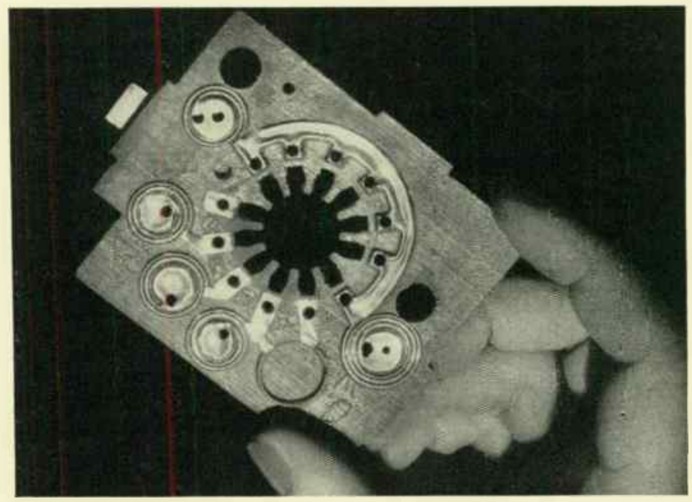
Perfect Umpire—The motor and pump in the household refrigerator or beverage cooler had to be tested and checked for many things electrical and mechanical: motor starting current, no-load watts, full-load efficiency, fan efficiency, leaks in the system, tightness of joints. Each of these was a separate operation for a tester, who made the appropriate connections, then read in sequence the proper instruments and gauges. In the great majority of cases the assembly passed unquestionably; a few with equal certainty did not. But then there were borderline cases. These involved judgment—the human factor—which even with the skilled, conscientious worker is apt to be inconstant.

Now the testing is done by a machine. The operator simply places motor and pump in position. The device runs through the complete cycle of tests, electrical and mechanical, flashing indicator lights to signify its progress. Finally it lights an "OK" lamp; or if trouble is found it stops the cycle at that point, leaving a lamp lit to indicate the particular difficulty. The operator meanwhile is placing the next unit in position on the two-place test stand. The machine is impartial, unaffected by headaches, always makes the same judgments. Borderline cases—some of which might mean trouble upon reaching the kitchen—are eliminated. Quality uniformity is improved. And a workman can test from two to three times as many units in a day with less physical exertion and fatigue. It's another notch in technological progress.

Fewer Backaches in the Foundry—Iron casting, one of the most ancient of metal-working arts, has been one of the slowest to modernize. The foundry has been famous for much shoveling of sand and much lifting of molds; for great clouds of dust, and intense heat from the melting furnaces, the pour, and the red-hot castings; and for dim lighting.

In the foundry that makes castings for refrigerators and other appliances things now are different. Casting manufacture is thoroughly conveyorized and mechanized. Sand and clay are mixed in large hoppers by machines, carried on bucket conveyors to overhead storage bins, and dispensed by gravity in measured amounts to the mold frames, which are brought to the operator's waist-level working position by conveyors. The sand is settled and packed and the frames stripped off by machines, and the sand mold carried by powered conveyors to the casting position. The cast pieces are automatically stripped of the sand mold. Even the hot castings en route to the cleaning station are purposely routed on overhead conveyors outdoors so that much of the heat is dissipated outside the foundry. At every step gratings allow excess sand to fall through the floor to moving belts that deposit it in hoppers to await reprocessing.

The greatest benefits are human benefits. The foundry air is kept free of dust by large suction fans; the human lifting effort has been reduced from 1500 tons a day to less than 300. The air temperature is comparatively comfortable. Light is excellent throughout the foundry.



The coils in this television tuner were stamped from the sheet metal and imbedded in the insulation all in a single operation.

But the product benefits too. Molds are more firmly packed; castings are more uniform, and productivity is increased by a considerable factor.

Television Tuner Circuits—Cookie Style—The heart of a television set is not, as it might seem, the picture tube. It is the tuner, by which the user selects one of twelve channels. In part it consists of parallel phenolic insulating wafers to which are attached small, flat, spiral coils, tiny but of exact impedance. A single tuner may have three dozen such coils, each with its soldered terminals, all in an area no larger than a playing card. Heretofore each of these had to be formed by hand and individually attached to the insulating wafers. A tedious job that left much opportunity for variation.

The new way is an adaptation of a method developed by the Franklin Airloop Corporation. A sheet of tinned copper is laid over the phenolic wafer. Then in a single operation the spiral coils—much like a flat, spiral paper clip—of exact dimensions, are stamped out of the sheet in a press and imbedded in the insulation. Done in a twinkling—and every part exactly alike.

Revolutionizing Plastic Mold Manufacture with Metallurgy—Nearly one third of all molds for Westinghouse plastics are made by hubbing, in which a hardened master die is forced into a block of soft steel to form a cavity of the desired size and shape. Up to now the metals used for the mold were soft, low-carbon, low-alloy steels. To withstand the stresses of compression molding of high-strength thermosetting plastics, these molds are hardened by pack carburizing and liquid quenching after forming. This heat treatment often renders a badly scaled, cracked, or distorted mold. Materials engineers recently established a landmark in the metallurgy of plastic molds by developing an alloy steel sufficiently soft to permit easy hubbing, yet with properties that enable it to be gas carburized in an Ammogas furnace, using an atmosphere of hydrogen and methane, and hardened by simply cooling in the protective cooling chamber. The resultant product is clean and bright, crack-free, and virtually free from distortion.

Better Radio Cabinets—Plastics engineers might be entitled to recast Herodotus' famous tribute to the postman. It could with justice be rephrased to: Neither cigarettes, nor al-

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cohol, nor bumps, nor other careless accidents, stay this plastic from the completion of its task as a beautiful and durable cabinet material. The recipient of this tribute is a new Micarta material that is resistant to just about every form of marring to which a wooden cabinet is susceptible. Furthermore, it is every bit as attractive in appearance because the surface layer is a faithful, printed reproduction of natural wood.

Heat-resisting qualities are given the plastic by a phenolic resin binder in the laminate. The Micarta is inherently resistant to alcohol and solvents, and has an abrasion resistance five times that of the usual phenolic impregnated wood-print laminates, because of a paper overlay that gives an extra wearing surface above the printed pattern.

Perhaps the most important feature from a manufacturing standpoint is that this material can be molded in many complex shapes and to reasonably close tolerances. Parts of a wooden cabinet are not ordinarily interchangeable, but with Micarta parts assembly-line production is possible due to the fact that precision molding is used. Furthermore Micarta is ready to use the minute it is removed from the mold—no surfacing or contouring operations are necessary. In this state the material can have either a high gloss or a satin finish, as desired for the particular application.

Prophecy Fulfilled— Almost seven years ago Dr. W. Edward Chamberlain stood before a group of radiologists in an annual convention and delivered the annual Carman Lecture. At one place in this interesting discussion Dr. Chamberlain ventured into the field of prophecy. He spoke of the greatest need in radiology—a bright-image fluoroscope. He pointed out how, with existing fluoroscopes, the operator must first spend a half hour in the dark to permit his eyes to become sufficiently "dark adapted" to discern the extremely faint images on the screen. And that even then it is difficult to differentiate between objects of similar density. If a screen brightness sufficient for observation and clear discernment of detail could be obtained, medical diagnosis would be greatly expedited and the results vastly more informative and accurate. It would, in short, be a development in radiology second in importance only to the initial discovery of the x-ray.

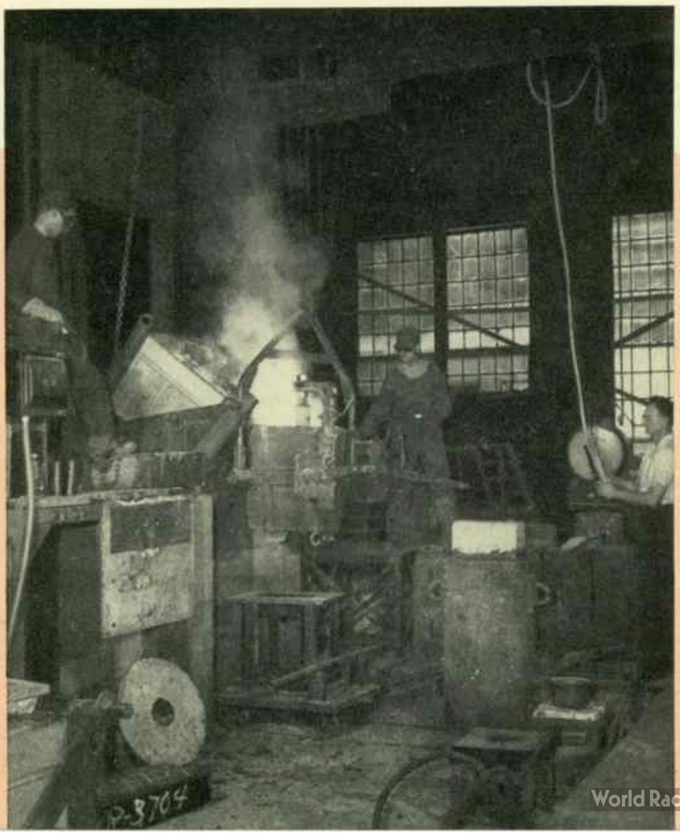
Dr. Chamberlain predicted that the need would be filled, even though there were many difficult problems to be solved at that time. There was no prospect of achieving the objective by increasing the quantity of x-rays passing through the patient. This could not be done with safety to the individual. There remained only the possibility of using the emerging x-ray beam to actuate an amplifier.

At first it seemed hopeless, but last May engineers announced that success seemed not only possible but also likely. An electronic fluoroscopic image amplifier has been made, and the pilot model has already given a five-fold improvement of the image. Research information has been acquired that will permit extending this 500 times. A tube designed to produce such image amplifications is now being built.

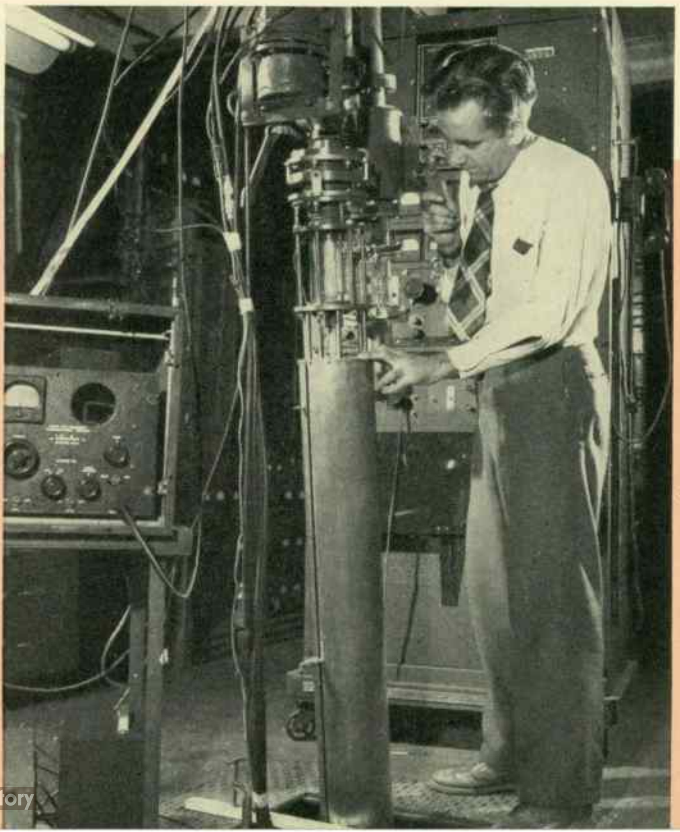
The system is this: x-rays fall on a fluorescent screen inside an evacuated tube; the inside of the screen is coated with a photosensitive substance, which emits electrons in proportion to the light falling on it from the fluorescent screen; these electrons are accelerated and focused on a small screen $\frac{1}{25}$ of the area of the original screen by a surrounding electrostatic field. The brightness of the screen on which the electrons impinge is increased per unit area 25 times because of the reduction in size. The acceleration across the tube increases the brightness by 20 times. In the total process then, the intensity of the image will be stepped up 500 times. It appears that the prophecy will be fulfilled.

Nuclear Threshold Voltages Determined Accurately — Although scientists have produced an atom bomb, have done years of research on the atom and its structure and behavior, the surface of atomic research has hardly been scratched. The reactions that occur in many given instances are known, but as yet their causes, or for that matter, even the true nature of the reactions is not apparent. Years and years of careful investigation lie ahead before highly accurate results and figures will be available to all researchers.

The induction furnace continues to give birth to new metals. Most recent is Discaloy, a high-temperature alloy for use in jet engines.



Continuing the intensive scrutiny of the inner sanctum of the atom is the work in the precision Van de Graaff atom smasher.



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One investigation now being pursued is the accurate determination of the threshold voltages of elements, i.e., the voltage at which artificial radioactive transformations commence in a nuclear reaction. For some nuclear materials this is a sharply defined point. The location of these threshold points is important to the scientist in that they can be used to aid in determining the masses of elements, and in similar experiments energy levels may be determined.

Nuclear voltage thresholds have been measured before, but not to the high degree of accuracy that scientists require. The procedure used in the new method developed by the Westinghouse Research Laboratories gives a heretofore unobtainable preciseness. The equipment used consists of a 70-megacycle resonant tube, through which the ion stream from a Van de Graaff generator is fed. Inside the tube is a second and smaller tube, arranged such that the ends of the two tubes form sets of parallel plates. The intensity-modulated ion beam produces an r-f voltage in each gap by induction. A probe is inserted in the side of the outer tube and connected to a receiver and instruments. When the two gap voltages are 180 degrees out of phase a minimum receiver signal results. At these points the voltage can be calculated from known values and instrument readings by a relatively simple formula.

A scientist, using this device, can watch for the first release of neutrons in the nuclear reaction, then note the meter reading, and calculate the threshold voltage. Already determined to an extremely accurate degree is the threshold voltage of lithium—1.882 megavolts. In the near future many other thresholds will be determined by this precise method.

Investigations of such things as threshold voltage—although not glamorous or spectacular—are a very necessary part of the accurate determination of the construction and reactions of the various particles that make up the atom, and of the forces that bind them together.

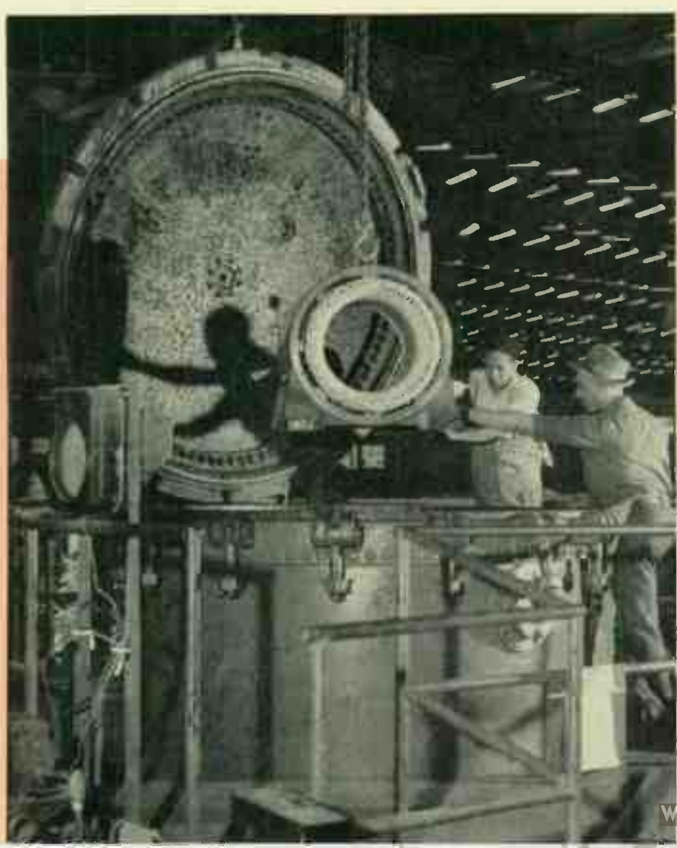
Metallurgists Sort Micron-Sized Rocks— In one respect the civil engineer has much in common with the metallurgist—both are concerned with the size of the rocks or particles that go into the mixes they use. While the scale of the problems is vastly different, both the texture and the strength depend upon the particles that make up the material—whether it be the concrete of the engineer or the molding materials of the metallurgist. Fortunately for the civil engineer the concrete maker has pretty well mastered his process, but the metallurgist still has a long way to go. His materials are more extensive and his problems greater, and the full effect of particle size distribution in a metal is just beginning to be realized.

As it turns out, the small particles of the metallurgist seem to act pretty much like bigger stones of the concrete maker. A material made of large particles—while strong—has a coarse surface; conversely one made of small particles has a smooth surface, but is more subject to cracking. In addition, the latter material often traps gas pockets and retains them, thus weakening the structure. To the metallurgist these are not satisfactory features in either extreme, and a good balance between the two qualities is highly desirable. An ideal example, incidentally the principal object of current investigation, is the problem of making molds of suitable quality for precision castings produced by the "lost wax" process. When particle size of the investment material is carefully controlled the number of rejected castings due to poor surface or lack of strength of the mold drops sharply.

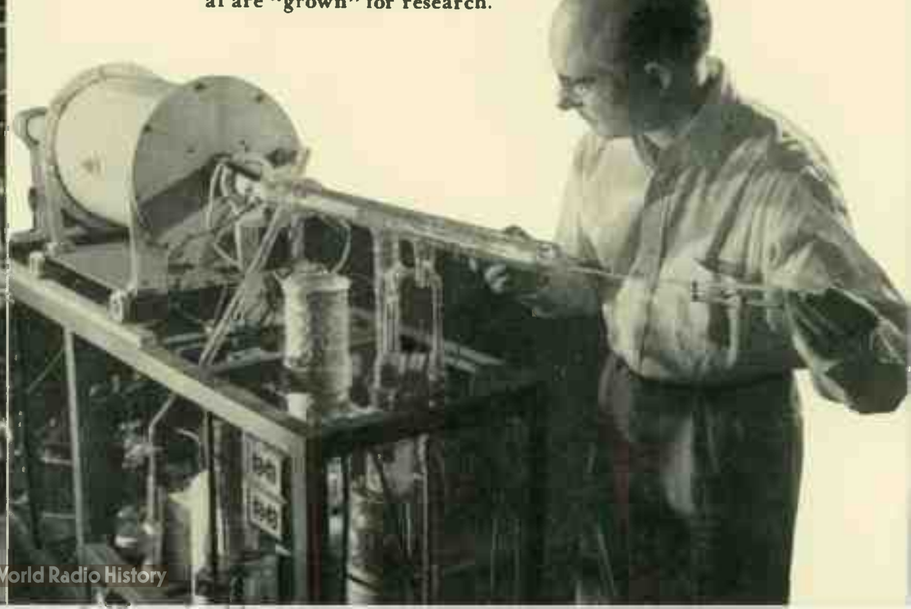
The first step in obtaining the balance of a strong but smooth mold is to measure the size of the particles—definitely not as easy as measuring rock sizes but nevertheless accomplished in much the same manner—by the use of screens. Here the metallurgist runs into his biggest problems. Extremely small screens graduated in size can sift out the particles down to a certain size—about 100 microns. Below this size the fine particles tend to stick together or the smaller particles adhere to the larger ones. Two consecutive screenings of the same material would therefore not give the same results. Below the 100-micron size a sedimentation method was found to be most accurate. This is analogous to dropping a shovelful of gravel into a pool of water—the larger rocks sink at a faster rate, while the sand takes considerable time to reach the bottom. Sedimentation rates depend on particle weight, and thus, in this case, size, since all are of the same material. The viscosity and density of the liquid used also affect the sedimentation characteristics, so this phase was also carefully investigated.

To illustrate the magnitude of the operation it is necessary only to point out that in the material tested each cubic inch contains one hundred billion (10^{11}) particles. Out of these,

The vacuum impregnation of preformed windings illustrates the constant revision of methods to produce better machines, quicker.



We have here a "hot house" where single crystals of metal are "grown" for research.



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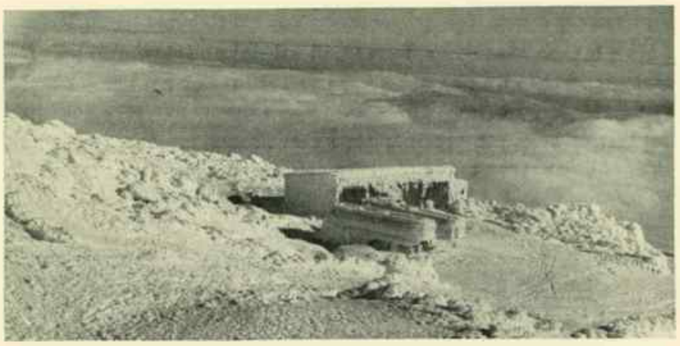

This well-iced scene is atop Mt. Washington, in New Hampshire, chosen as the scene of research on icing of jet-propulsion units.

95 percent of the total weight is concentrated in only about 1000 of the particles. The task was not easy.

A corollary but nonetheless interesting application of this investigation is in the manufacture of Coronox, the semi-conductor material coated on the conductors of high-voltage generators to prevent electrostatic discharges. Since the effectiveness of this semi-conducting pigment depends upon a carefully maintained resistance, it is important that the particles of material be close together. The particles are inherently of low resistance whereas the spaces between them are of comparatively high resistance, making it desirable to use small particles. However, the problem is not this simple. If particles are too small the varnish that coats them causes an undesirably large spacing, thus increasing resistance. Particle size must therefore be controlled very closely in order to obtain the optimum effect. As materials become more and more complex and their uses more and more specific, the need for widespread accent on particle size determination will become increasingly necessary.

Useful Rust—To a true scientist every material has a potential use—even rust. About three years ago materials engineers began to look around for some means of putting iron oxides to work. They found that since it was a good electrical insulator, it might well have possibilities as insulation between motor laminations. Iron oxide coatings were found to be satisfactory, but results were not uniform.

Recently materials engineers discovered the reason—the coatings were not of the same iron composition even though no difference was apparent to the naked eye. Being of different composition, the oxide coatings naturally had different resistances. The reason for the nonuniformity was due to the temperature at which the oxide was formed. Oxides formed above 570 degrees C have low resistance, since FeO is formed at this temperature and subsequently decomposes into free iron and Fe_3O_4. The lack of uniformity was overcome by a combined annealing and oxidation procedure. The electrical sheet steel was placed in a heat-treating furnace, annealed in the proper atmosphere, then brought down below 570 degrees C for the steam oxidation. Bringing the temperature down below this level assures a more uniform oxide film, and thus renders a sheet of steel complete witn electrical insulation.

A Summer Playground Becomes a Winter Research Laboratory—Mt. Washington has long been an attraction to summer vacationers and sight-seers. But it is a formidable place in the winter. That very fact, however, has attracted to it new kinds of visitors—research men bent on ascertaining what the arctic conditions atop Mt. Washington will do to jet engines. Mt. Washington has become a nature-provided proving ground for the services and jet-engine builders functioning cooperatively.

This more than 6000-foot-high mountain at Gorham, New Hampshire, experiences some of the worst winter weather of the North American continent. The combination of wind speeds up to 100 mph, air temperatures down to at least 40 degrees F below zero, continual icy fogs and rain, snow, and ice, are more extreme by far than at any other spot in the continental United States.

These local weather conditions are the result of peculiar circumstances that cause "icing" phenomena to occur there for six months of the year. Cold air masses moving down from Canada are forced to climb over the mountain range to which Mt. Washington belongs. During the climb the air speed increases, as during flow over any protuberance (hence high wind speeds). More important though, is the reduction in air pressure at increasing altitudes. As the air rises into these lower pressure regions, the air temperature drops and part of the moisture in the air condenses in the form of droplets. Various sizes of water droplets are formed, but, on the average, the drop diameter is about ten microns. Because of these small drop sizes, the surface tension forces per unit volume are large. The water drops are thus subjected to extremely high internal pressures and may not freeze at temperatures as low as minus 45 degrees F. When these drops impinge on a surface, however, their shape is distorted and the internal pressure is released. Freezing then occurs instantaneously.

Turbojet engines consume huge volumes of air. Under icing conditions, therefore, they draw in large numbers of sub-cooled water droplets. These droplets tend to freeze onto the surfaces of the forward portions of the engine. Under severe icing conditions the flow area may be blocked off in a matter of minutes by ice, to such an extent that the power of the engine is reduced considerably.

With answers to such questions as—what parts ice over? how rapidly does this occur? how much power is lost?—engineers can go to work on the task of building engines less troubled by icing difficulties.

This should never happen to a radio, but if it did the surface of this beautiful wood-grained plastic material would be unharmed.

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. . . . . and many more

In the preceding pages, about 65 subjects have been touched on briefly or at some length. They illustrate, we believe, a wide variety of engineering developments and the several phases of engineering between original research and final application. Also these stories bear out the editorial thesis that a year's review of broad engineering manifests a few leaps of spectacular length interspersed among a multitude of slower, less flashy progressions. In addition to those for which space was available, many others could have been presented, perhaps fully as worthy and as interesting.

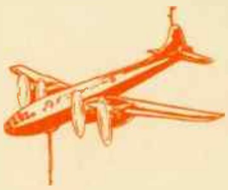
In discussing new light sources we need not have dwelt exclusively with vapor lamps, which, because they are relatively younger, are more subject to conspicuous development. We could have discussed at some length interesting new aspects of much older *incandescent lamps*. . . . A new *lamp for night sports* has been developed. The light output during its life is maintained at a higher level than before. The problem with such lamps, which are burned on overvoltage to give more lumens per watt at a sacrifice in life, has been the matter of condensation of tungsten on the bulb interior, diminishing the light output. Now a strategically placed mesh of nickel is set above the filament in the path of the circulating gas and by its relative coolness condenses the tungsten before it can reach the glass. . . . *Colored lamps*, used by the millions, particularly for electric signs and theater marquees, demonstrate an interesting cycle. The coating of color is now on the outside of the glass, as it was 25 years ago. This time it is baked-on ceramic enamel, which is permanent, better in appearance, and more efficient in light transmission. . . . The *one-watt fluorescent night light*, developed several years ago but tripped on its way to production by the war, is now available in quantity. Already it has saved many stubbed toes, barked shins, and worse in the American home. . . . *X-ray tubes* now have a longer life and are smaller. Primarily this comes about because of an improved cooling system, in which oil is forced through the anode by a motor of vest-pocket size.

Vacuum tubes are thought of as becoming smaller and smaller—even to the size of grains of corn. On the other hand, some are very large and massive indeed. For industrial heating and large broadcasting sets, air-cooled tubes have weighed up to 225 pounds, most of this contributed by the several dozen copper cooling fins. This weight has made handling in narrow confines difficult as it requires the strength of two people in a space big enough for only one. A new technique, developed in cooperation with the Al-Fin Division of the Fairchild Engine and Airplane Corporation, allows aluminum fins (instead of copper) to be cast around the tube wall. The resulting tube (not yet in production) weighs only 98 pounds.

The ratings of *disc-type rectifiers* continue to rise in two directions—voltage and current. By a new and somewhat involved processing technique the direct-current or output voltage of a single selenium disc has been raised from 12 to 24 volts. This effective one-half reduction in size encourages the use of selenium rectifiers for high voltage. Several have been built oil immersed for a 70 000-volt, 5-kw, d-c output for a dust-precipitation application. They are also being used as high-voltage rectifiers for radio broadcasting.

In the *central-station apparatus* field it is interesting to note that the size of air-cooled feeder voltage regulators is increasing. A 96-kva, 2400-volt unit is now available. This lifts the maximum capacity of air-cooled regulators by one third. . . . A southern utility is finding very useful a polyphase combination watthour and thermal *ampere-demand meter*. . . . *Ground-fault neutralizers* are finding some increase in favor. Last year a very large one rated 160/120 amperes was installed on a 69-kv system in the midwest. . . . For powerhouses where a large quantity of condensing water must be circulated a new *high-pressure, multi-stage propeller pump* provides advantages over the slow-speed centrifugal pumps heretofore used. It is very much smaller and has somewhat better efficiency. Propeller pumps have previously been limited to pumping heads of not more than 25 feet.

A *progress report* should be given on several major developments mentioned previously in these pages. *Stratovision*, for example, is proceeding according to plan. The Stratovision plane equipped with picture-transmitting equipment was given its first public trial in broadcasting the events of the Republican Convention to listeners in Western Pennsylvania, Ohio, and West Virginia, and gave a further successful demonstration of effectiveness with a broadcast of the last of the World Series baseball games. The Federal Communications Commission is now studying applications for licenses for Stratovision stations on one of the new high-frequency television channels. . . . Three of the *x-ray thickness gauges* are now in service and have accumulated about a year's service each. A new gauge, being developed, will simplify the matter of changing the standard when different thicknesses of material are to be processed. . . . The *computing center* using the new, extremely large analog computer (Anacom) has been functioning almost a full year and has saved untold hours in solving problems in the fields of hydraulics, mechanics, thermodynamics, and electricity. . . . Development of the principle of *periodic reverse-current plating* has been enormously accelerated by a new laboratory built especially for that purpose. In the first six months of its operation some 8000 samples have been plated by this new technique, including a wide variety of automobile parts, engravers' plates for printing, and master phonograph disks. Some commercial installations employing the principles are already in service, the largest being for the plating of copper on steel for automobile trim.



And now, as we reach the end, we still have a miscellany of items that must go unmentioned. But better still we have a goodly list of interesting subjects that because of their present state of development, are left in a folder marked "Next Year's Highlights."

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Movable bridges should have good appearance, and provide reliable service with least delays. This one between Terminal Island and Long Beach (California) is typical. The movable section, counterbalanced so that its 800 tons is reduced to a one-ton lift, is raised 125 feet in 2¼ minutes, by double-motor drives in each pier, with synchro-tie control.

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