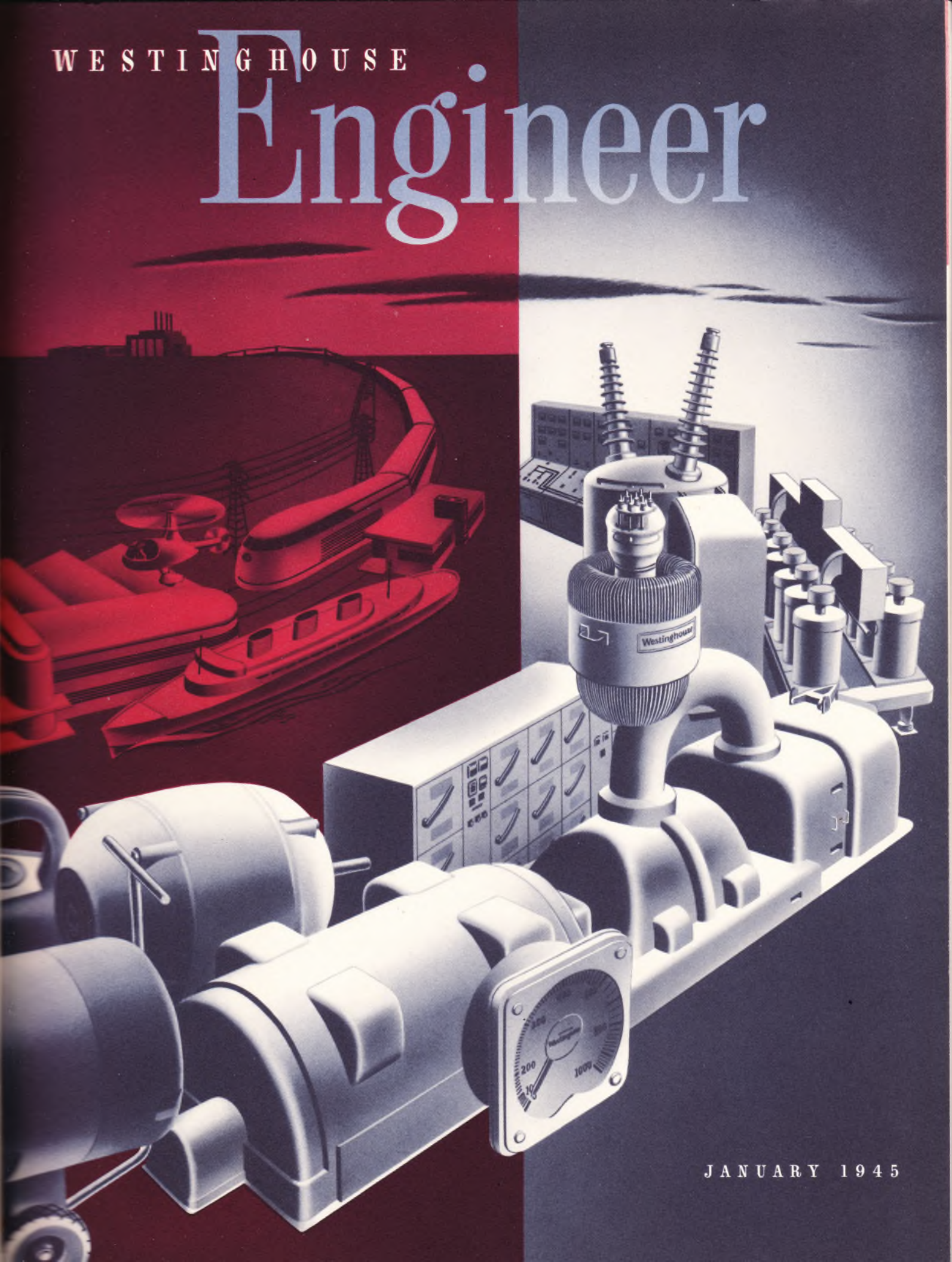
WESTINGHOUSE

Engineer



JANUARY 1945

The basis for Industrial Leadership

WORLD industrial supremacy of the United States has been built principally on three things; huge natural resources, production ability, and technical skills. Two of these are disappearing. These two are raw-material resources and the ability to outproduce by mass-production methods.

The war rudely jolted us into realizing that our natural resources are not inexhaustible, as was once thought. Our lush forests have been decimated. The end of our rich, easy-to-get surface strips of iron ore is not many years distant. The zinc and lead of Oklahoma have almost run out. Our petroleum reserves, although not positively known, at present rates of use are variously estimated to last from 10 to 30 years. We are, to be sure, not yet impoverished, but whether underground supplies of many indispensable minerals last for 5, 10, or even 50 years, the fact remains that they are expendable, and we are expending them at furious rates.

Our ideas of self-sufficiency have been sharply revised. War experience with tin, rubber, manganese, and other essential materials demonstrates we cannot, as a nation, lead an isolated existence.

"Made in USA" has been a symbol of goods in demand around the globe because of our ability to produce necessities and luxuries in veritable floods, of good quality, at low cost, and of identical, interchangeable pattern. But in this skill we possess no permanent monopoly. Other peoples are learning our methods. It is no secret that mass-production methods are being adopted in many countries where only handcraft-production methods have prevailed. No doubt our industrialists will, for a long time at least, be able to produce in greater volume and quality than the less-experienced peoples. But, the great gulf of advantage possessed by a mass-production nation over handcraft peoples is due to diminish.

Ingredient number three of our industrial strength is many things. It is technical skill. It is mechanical skill. It is research. It is imagination and the ability to conceive human wants before people are aware of them, and to fashion devices, machines, methods of supplying them. It is the ability to reduce discoveries and inventions to products that can be made in large quantity at low cost.

On this quality of our nation rests our continued leadership. This resource is not expendable. Neither is it something we alone possess. But it is cumulative in roughly geometrical ratio; it is sharpened by competition. Furthermore, the stock of "know-how" already amassed is enormous. As if to substantiate this, there continues to pour forth, in war as in peace, a flood of new discoveries, newly clarified principles, new products, and new machines. This uninterrupted flow of contributions by men of science and engineering gives concrete evidence of the virility of that fundamental strength of American society—leadership in technology.

These things give assurance that American pre-eminence will not suffer any blight in the foreseeable future and point to the need for spending larger sums and greater effort to augment this great American resource. There must be no relaxation in our encouragement and positive support of those things that bulwark our strength in technical fields—technical education of our young men and the institutions that provide it, research laboratories both private and public, and the engineering laboratories both large and small.

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Engineer

VOLUME FIVE JANUARY, 1945 NUMBER ONE

On the Side

The Cover — Across a background of uses, the physical handiworks — today and tomorrow — of the scientist and engineer make a continuing parade.

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As an exception to the adage of the shoemaker's children, Westinghouse has adopted radio as a means of communication for the railroad system at its own East Pittsburgh plant. Five locomotives and the central dispatcher's office are being equipped with frequency-modulation radio sets. The system is expected to speed up switching operations on the 25 miles of track within the 174 acres occupied by the company's plants.

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Born of research and the cooperative effort of several companies is a new material able, literally, to withstand the fires of combat. It is a laminated plastic board for switchboard purposes, custom-made to suit the requirements of the Navy. It is fire resisting. The laminations are of glass cloth, itself inorganic and noncombustible. The binder is melamine formaldehyde, a thermosetting resin that does not support combustion.

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A major improvement has been effected in power-line carrier, by which voice, supervisory-control, and relaying signals are transmitted over the line conductors. It involves the transmission of only a single side band of frequencies. The fundamental frequency and all those in the other band are omitted. This in effect doubles the number of channels available with either of the conventional amplitude- or frequency-modulation systems. Energy is required only when signals are actually being sent.

In This Issue

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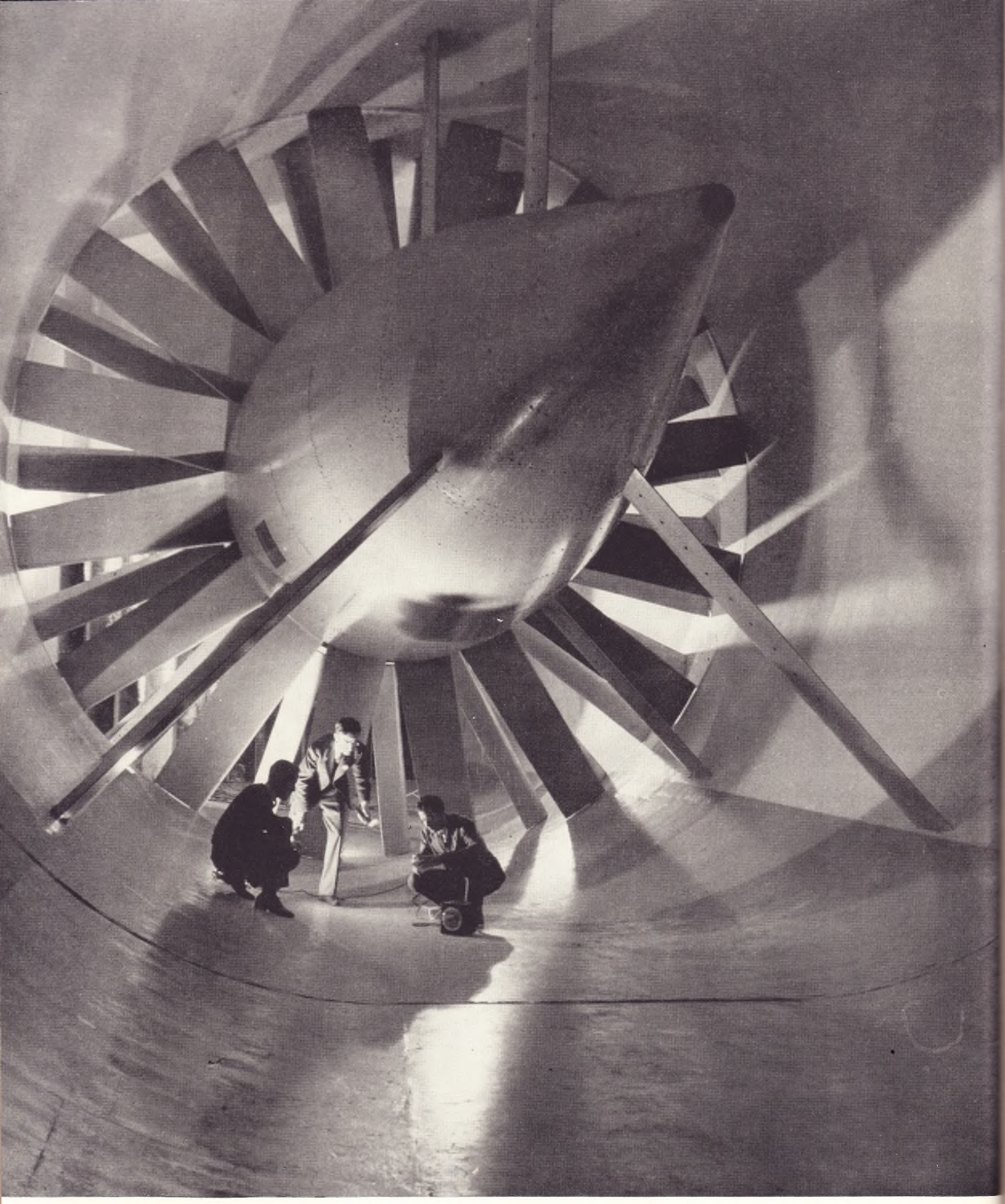


In wind tunnels like this, tomorrow's airplanes are born. The 24-foot fan of the Allen Memorial Aeronautical Laboratories is powered by an 18 000-hp motor. (Photo courtesy Boeing Aircraft Company, Seattle.)

Where There Is Sound There Is Activity

Those passing by a remote end of a Westinghouse plant any time during the past several months would have heard a deep-throated roar, much like a battery of furnaces under heavy draft. This almost continuous sound comes from a group of masonry test cells where gas turbines have been in the course of testing for many months.

Contributing its full share to the low rumble is a jet-propulsion engine under development for the Navy, Bureau of Aeronautics, the first to be undertaken in this country free from foreign influence. When the development is completed this new engine is expected to produce more pounds of thrust for a given weight than any engines brought from Europe for study. This engine is expected to be important for future aircraft service.

Few subjects in recent years have been studied so assiduously; few have commanded so much research work, so much laboratory experimentation as have gas turbines, of which jet-propulsion engines are but one form. Actually an enormous amount of ground has been covered. Probably more has been accomplished in the past two years to make the gas turbine widely practical than in all its previous history, which had a very early beginning.

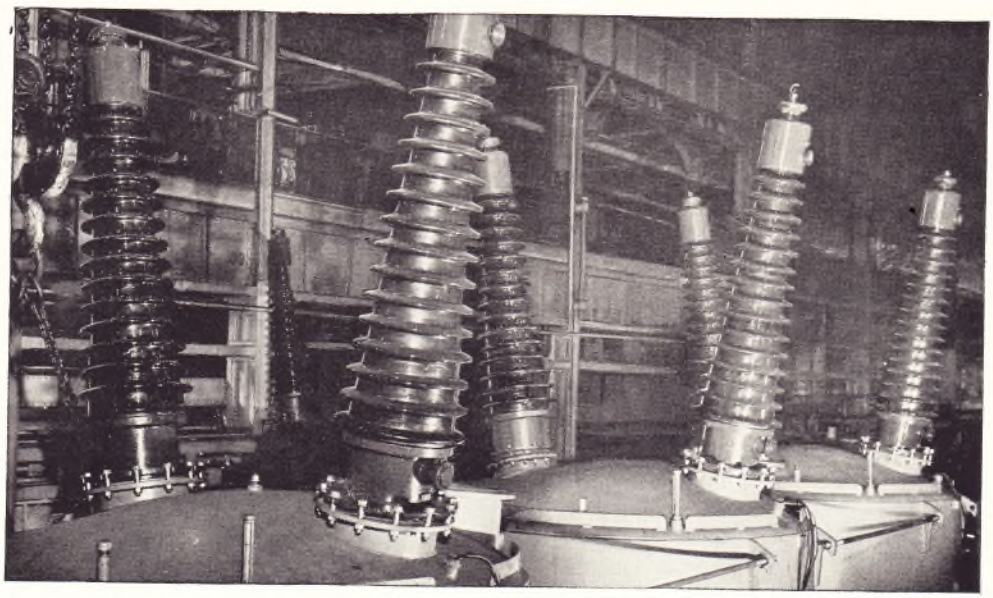
Essentially, work of three sorts is being done. One is in the field of high-temperature metallurgy. Success of the combustion gas-turbine cycle depends on the temperatures in the turbine itself being 1200 degrees F or more, which is well beyond the highest steam-turbine temperatures. The higher the allowable temperatures the greater the efficiency and the wider the field of usefulness of the gas-turbine cycle as a prime mover.

A second and the most active phase of the activity is the design, building, and testing of different units with many variations as to size and arrangement. This includes designs for the three main components of a gas-turbine cycle—axial-flow compressor, combustor, and gas turbine—and the relatively few but important controls and auxiliaries.

A third activity—sharply limited by more pressing war work—is the investigation of possible uses of the combustion gas-turbine cycle. This involves extensive thermodynamic and heat-balance calculations for a wide variety of simple open-cycle systems, heat-recovery open-cycle systems, and closed-cycle systems all predicated on assumed efficiencies, loadings, and costs.

The great attraction of the combustion gas-turbine cycle lies in its simplicity, its independence of a water supply. Basically it consists of three units on a single shaft. Liquid fuel is burned with a great excess of air in a combustor. The hot products of combustion drive a gas turbine and, in the simple cycle, exhausts to atmosphere. The turbine develops power to drive an axial-flow compressor on the same shaft that supplied air to the combustor. Power from the turbine in excess of that required by the compressor can be utilized to drive a generator or some other mechanical load.

The efficiency of a 1200-degree F simple open-cycle gas-turbine plant is about 20 percent, which is only about two thirds that of a good steam or gasoline-engine power plant.



The new condenser bushings are, like modern transformers, built up of oil-impregnated paper insulation, vacuum treated, and hermetically sealed. The impregnated paper is made entirely adequate for insulation strength. The porcelain and the fluid oil between porcelain and the condenser are not relied upon for electrical strength. The absence of voids in the insulation increases the corona voltage and decreases the possibility of ionization of gases. Tests indicate great temperature stability.

Also all present combustors and turbines require liquid fuel. The unit, furthermore, is not self-starting. Its great advantages, on the other hand, are its simplicity, its light weight and small bulk, no need for water, and the absence of reciprocating parts. Efficiency can be increased 10 or 15 percent by adding various heat-recovery devices such as intercoolers for the compressor, regenerators for the combustor, and fuel reheaters. These, on the other hand, add complications. Some of these demand a supply of cooling water.

Open-cycle gas turbines with approximate maximum ratings of 7500 hp will probably be useful as emergency or stand-by generating units on power systems, particularly at the end of long lines or where good or adequate boiler water is lacking. To obtain larger amounts of power for central-station use from units of practical size will require a closed-cycle system in which the hot gases are continuously recirculated at higher pressure. Certain special industrial applications look promising, such as power supply for blast furnaces. Also the gas turbine is attractive for ship propulsion and for electric-drive locomotives, particularly because of the water economy.

Better Bushings Are Built

THE familiar high-voltage condenser bushing has experienced a threefold improvement, each of which is of major significance in its performance as transformer or breaker terminal. The new construction, in fact, borrows heavily from modern transformer practice. The new bushing insulation is built much like transformer insulation that has proved so successful. Three basic principles of construction underlie that success. One is the use of organic insulation that, after assembly, is thoroughly vacuum treated to remove all moisture and gases. This includes the gases that are trapped between structures and those actually within the insulation itself. A second basic requirement is to oil-impregnate the insulation while in the gas-free condition with degassed hot oil under pressure. This insures complete filling of all voids and interstices with oil. Finally, the bushing is sealed hermetically so that this moisture- and gas-free condition is retained.

The new condenser bushing consists, as always, of layers of high-grade paper, wound under tension on the copper conductor, which is a copper tube or stud. In accordance with well-known condenser-bushing principles, sheets of metal foil are inserted at intervals. Except for an adhesive to bind the first turn of paper to the conductor, the paper is wound dry, with no binder between layers, as in the best modern transformer practice. There is, likewise, no subsequent varnish treatment of the insulator surface to interfere with oil penetration. After the winding has been made in this manner—usual except for the absence of the shellac between layers and the final varnishing—and is machined to proper dimensions, the structure is placed in its porcelain housing. In the new bushing, the condenser is completely enclosed by upper and lower porcelains connected at midsection by a steel sleeve. Thus the condenser projecting down into the tank is encased in porcelain as is the upper end.

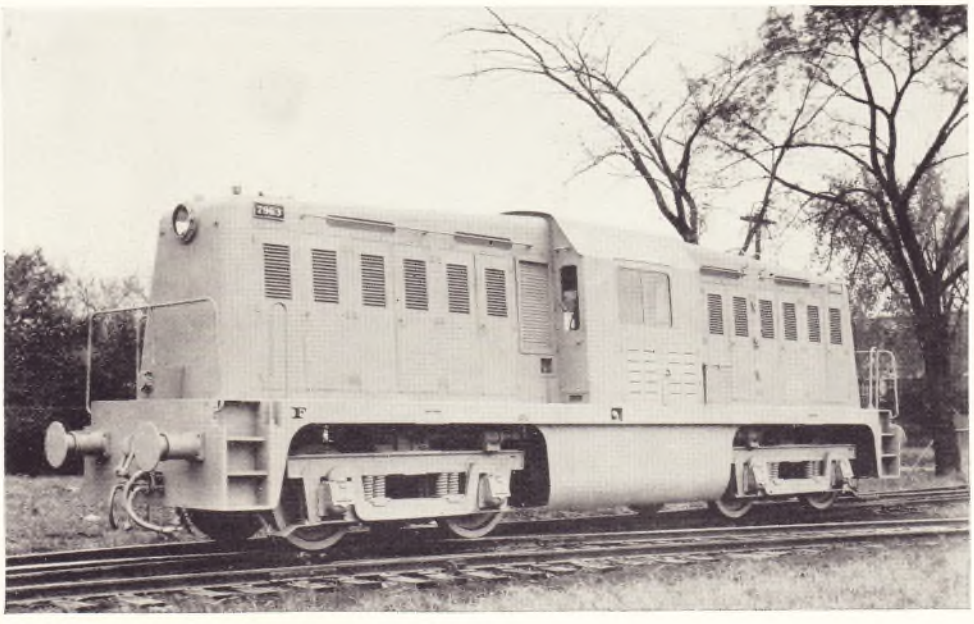
In this bushing the mechanical and electrical functions have been entirely separated. The condenser no longer assumes any of the mechanical load. All stresses are carried by the porcelain in compression. Completed bushings of this design have been subjected to severe shock and vibration tests with results that proved the porcelain and steel structure to be adequate.

Although these condenser bushings are physically much smaller and lighter than any other type of high-voltage terminal (a fact of great importance with transformers and breakers becoming smaller) the dimensions of flanges and adapters make them interchangeable with older condenser bushings and with other types of high-voltage bushings.

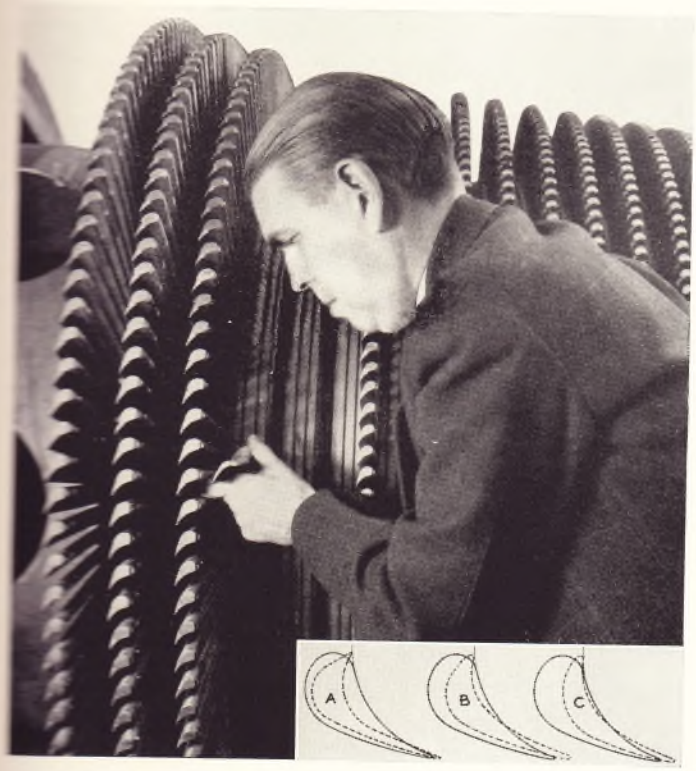
Power Trains Help Europe Rebuild

NOTHING cripples a modern city like the lack of electric power. The destruction of power plants by retreating armies and the rebuilding of them as the first order of business by the victors testify to that. One expedient to hasten the availability of electric power in a war-torn land, or for that matter on any other occasion when emergency power is needed, is the power train.

A total of thirty-four of two sizes of power trains have been built for European service. One is a 5000-kw unit requiring a train of eight cars and the other for 1000 kw, in three cars. Each train is a complete power plant, requiring only a supply of coal, make up water and connections to the power-receiving lines. A source of cooling water is not necessary, as the trains must be able to operate in regions where water is scarce or of poor quality. Water for steam is recirculated so only a small



Several hundred diesel-electric locomotives like this are in service in North Africa and Europe helping with victory and reconstruction. Built by Whitcomb Locomotive Company with Westinghouse electrical apparatus, it is of a new type, developed particularly with the needs of war-torn areas in mind, and proves to have many desirable features that are expected to appear in switching locomotives for service in our railroad and industrial-plant switchyards. In the interest of weight, cost, and simplicity the exciters are not used. This results from the development of self-excited generators, the largest ever built for railroad service. They are rated at 305 amperes, 305 volts, a pair comprising the electrical power plant. Four motors, designed to match the generators, are used, one per axle. Two motors are permanently in parallel for each generator.



A new reaction blade for steam turbines has a cross section like an airplane wing with its blunt leading edge. It is compared in the inset with earlier blades, A, B, and C. At slight sacrifice in peak efficiency, high economy is maintained over a wider speed range, making this blade of value for marine and industrial service where variable-speed turbines are used. The heavier blade section also permits the use of the highly desirable riveted shrouds.

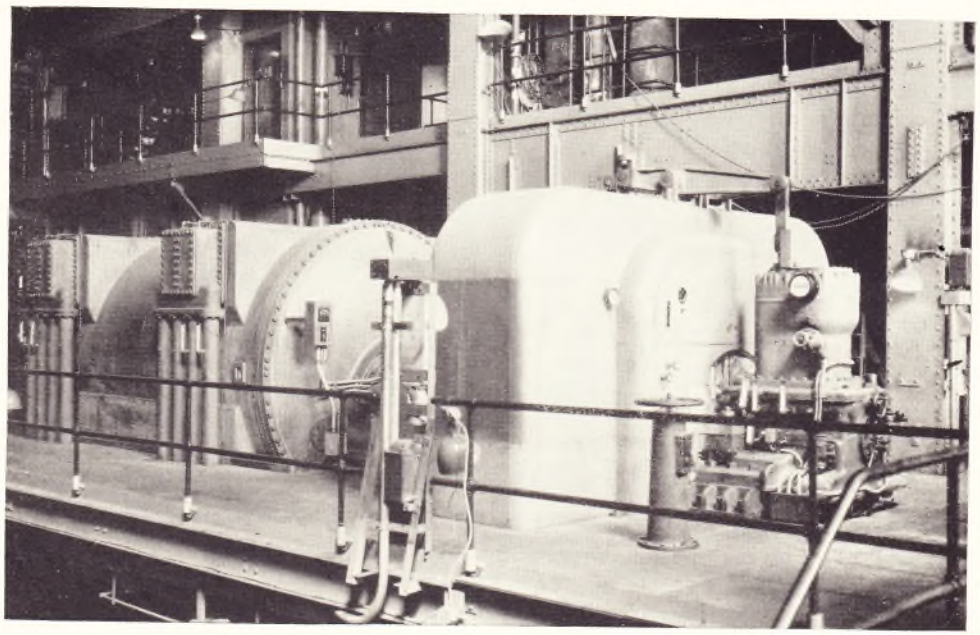
amount of water, carried in a water car, is needed to make up for losses. Special types of boilers for burning low-grade coals are supplied by Combustion Engineering Company and Babcock and Wilcox Company. The Westinghouse turbine, generator, and switching equipment do not differ radically from standard equipments. The 5000-kw train condenser, however, being air cooled, embodies unusual features. The condensing sections consist of numerous rows of finned, galvanized-steel tubes through which the turbine exhausts. Along the outside of the tubes air in great volume is drawn in and upward by motor-driven blowers. The condensers are designed for turbine exhaust of two pounds per square inch gauge at full rating over an ambient temperature range of −40 to +95 degrees F. Problems of possible freezing during periods of light load and cold winter air and the maintenance of equal steam division among the condenser tubes presented serious difficulties. Although the air-cooled condenser is unusual, the test results with the train prove it is entirely practical where lack of cooling water dictates its use.

New Relays for Transmission Lines

WHEN two parts of a power system joined by a tie line are separated by loss of the connecting line, one section may not have sufficient generating capacity to carry its loads. The frequency will begin to fall off so rapidly, perhaps, and to such an extent that the two systems cannot be resynchronized until important load has been dumped. To decrease the amount of load dropped and to do it on a preselected basis instead of in the heat of an emergency, a new relay responsive to change in frequency has been created. It is a relatively simple relay with a single electromagnet. Two balanced circuits are arranged so that a small change in power factor (brought about by frequency variation) makes large changes in current, which result in a high torque for the operating element. Relays were built for this purpose before, but they have been much more complex, entailing the balancing of two opposing torques (i.e., two electromagnets) on a single disc. The new relay is far superior in being independent of ambient temperature and in the degree of fineness of adjustment.

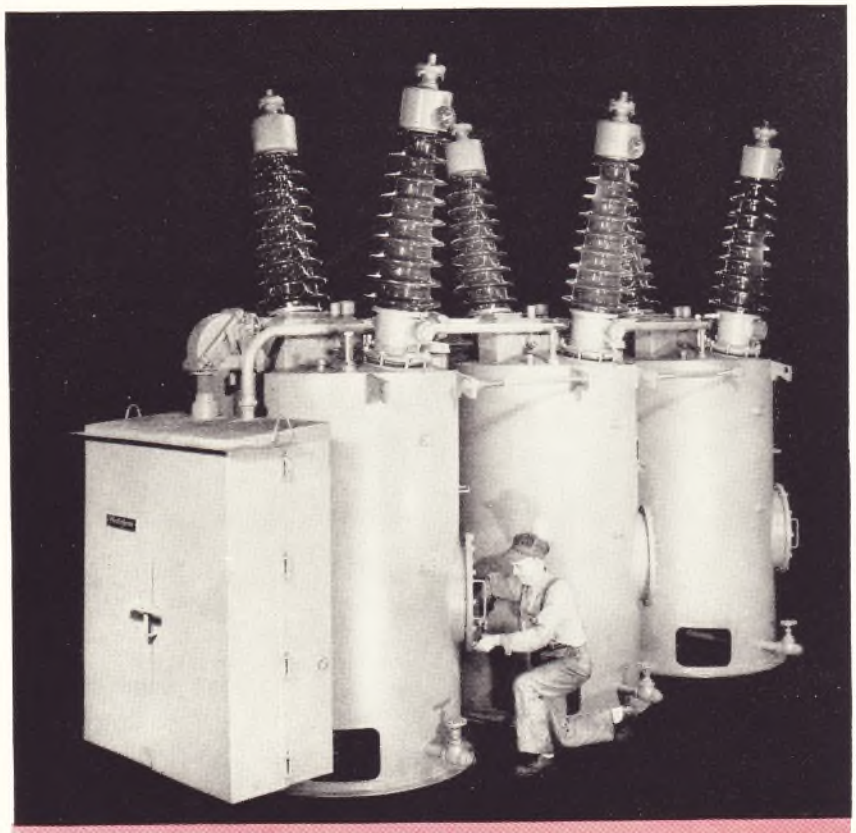
Another new frequency relay (labeled the CF-1) has other applications. For example, some of the war-born plants such as synthetic rubber factories have surplus electric-power producing capacity. The surplus power is fed into the local system. When, for any reason, the frequency on the public-utility system drops, the relatively small factory generating system tries to shoulder the whole load. The frequency relay causes the tie line to open, thus avoiding this condition.

Another relay development, that bears on the problem of holding together systems with single tie lines, is that of selective-pole tripping. This is really an important extension of an idea developed a few years ago, known as single-pole reclosing.



Two years' successful experience with steam turbine operation at 950 degrees F gives designers the confidence to take the next step, the construction of machines capable of operation at 1000 degrees inlet temperature. The unit shown here is the 50 000-kw, 1800-pound, 950-degree superposed turbine generator at the Sherman Creek Station of the Consolidated Edison Company of New York. This picture was taken before turbine installation was complete and with temporary control stands still in position. Operating experience with the 125 000-kw three-cylinder unit of the Burlington Generating Station of Public Service Company of New Jersey is equally gratifying. The increase in temperature of steam at the turbine inlet from 950 to 1000 degrees will permit a gain of nearly two percent in overall plant efficiency.

Four fifths of the faults on single-circuit lines are single line to ground. The single-pole reclosing idea, which has proved very successful, is to open and then reclose just that one line instead of all three. This allows the arc to go out, but holds the two ends of the system together better as to frequency than if they were cut entirely apart. In case of faults involving two or three phases, all phases are opened in the conventional way.



A product of the high-power laboratory, this 115-kv De-ion grid circuit breaker weighs 20 percent less, uses 30 percent less oil than older models.

The new scheme carries this idea further, to the opening of two lines involved in two-phase-to-ground faults or line-to-line faults, which comprise most of the remaining types of faults. This leaves one line tying the system together, which, although not so effective as two lines, does greatly reduce the tendency for the two systems to swing apart before reclosure.

An improvement on carrier relaying comes about with a relay (HKB) that bases its decision on whether a breaker should open or not on a comparison of the waves at the two ends of the line section suspected by the relay of being in trouble. The main features of the new relay method are that it uses one relay for all three phases instead of one for each, and, because it requires no voltage discrimination, no potential transformers are needed. It is also inherently free from interpreting an out-of-step condition as a fault.

More Breaker, Less Oil, Less Weight

In 1925 a 220-kv circuit breaker was built for the Conowingo hydroelectric development. That it was able to clear a fault in 25 cycles was considered a real achievement. With the development of the De-ion grid about 1930 fault-clearing times of 12 cycles became standard and 8 cycles available at extra cost. By 1932 the 8-cycle breaker was generally used and remained the standard for high-voltage oil circuit breakers until just a year ago when the fault-interrupting time was again almost cut in half. For breakers of 115-kv and above, five cycles is now standard for all ratings and three cycles at certain high interrupting capacities.

This remarkable decrease in fault-clearing times is accompanied by a great reduction in circuit-breaker size, an increase in maximum interrupting capacity, and faster reclosing speeds.

The new breaker uses from 30 to 50 percent less oil. For example, the 230-kv breaker requires only 8400 gallons of oil instead of 15 500. This means not only less investment in oil but less oil-storage and handling facilities, and less oil-treating equipment. The total weight of the breakers is cut roughly in half, the height reduced nearly a tenth and the floor space required by nearly a fifth.

For the first time a breaker is available capable of clearing 3½ million kva, a million more than formerly. Furthermore, this is accomplished in smaller tanks—such as for the 3½-million kva unit, a tank 84 inches in diameter instead of one that is 108 inches in diameter for the 2½ million-kva breaker.

The principal engineering feature that lies behind these improvements is a multi-flow grid in which oil is brought forcibly into contact with the arc as it is drawn. The same basic De-ion grid construction of a fiber laminated plate assembly is retained. However, the structure is arranged so that as the contacts first part a very short arc is drawn above the grid stack. This arc creates a gas pressure that squirts oil into the arc stream through a multiplicity of orifices in the grid. The large surface of cool oil in contact with the arc de-ionizes it at a rapid rate and results in its quick extinction. This mechanism of rapid arc extinction means that less oil is needed because the arcing time is shorter and the actual arc length is reduced. The arc voltage is so markedly reduced that it is difficult to find on many oscillograms of such operation.

In addition to the several advantages of a smaller breaker and less oil, the new breaker brings to power systems the operating advantages of greater stability and less damage from arcs on lines and structures.

Air-Cooled Distribution Transformers

In 1938 a 50-kva air-cooled distribution transformer weighed 1050 pounds. The 1942 model weighed 580 pounds. The ones built last year weighed 450. The weights for the 15-kva air-cooled distribution transformer for the corresponding years are 495, 245, and 200 pounds. These almost straight-line decreases in weight—over 60 percent in six years or about 20 percent in two years—and a corresponding decrease in bulk, are significant. Particularly in marine service, space is at a premium and light weights are desirable. The new editions of these transformers are produced with fewer man-hours of labor, which has permitted quicker production for the services requiring them. Largely responsible for the recent great reduction in weight, bulk, and time is a change in core material and assembly method. The old type of core built up by hand of individual punchings has been abandoned. Instead the core is a tightly wound, continuous coil of Hipersil, with a synthetic bond between each turn. This core is then cut apart, the

coils inserted, and the two sections placed together again with a bond between, and tightly strapped. This is the same core construction (type C) that has been used with great success on oil-cooled distribution transformers. The core is made of Hipersil, a grain-oriented magnetic material, which, because of its exceedingly high permeability in the direction of the grain, permits less of it to be used for a given size transformer.

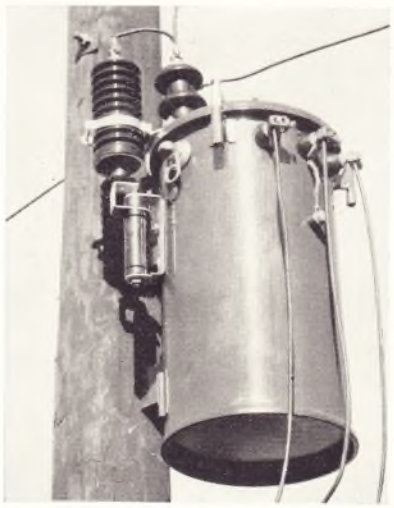
These same ideas have been applied to current and potential transformers also with important reductions both in size and in weight.

Distribution Transformers in Wartime

THE will to improve their handiwork is as natural to engineers as breathing. Even a war cannot squelch it. The distribution transformer is a good case in point. Rightly enough the government restricted the manufacture and purchase of these transformers close to the vanishing point. Furthermore the demands for engineering talent on direct war work left less time for regular transformers, which are a highly perfected device anyway that they seemingly could ride through the war without critical engineering attention.

But the hard-pressed power companies with war-imposed loads soaring needed every extra kilowatt of equipment capacity. Hence transformer engineers decided to see what could be done with those few new units that were permitted and those "refills" which power companies used to replace worn-out or damaged cores and coils in old units. The result, among other things, was a 10 to 20 percent increase in short-time overload capacity with no sacrifice in voltage regulation or increase in total losses at normal load. This was accomplished by using fewer turns (possible because the wound Hipersil core allowed a smaller window), which reduced the ratio of copper to iron losses. The result was a distribution transformer better tailored to wartime conditions.

The coil structure has been additionally improved by adoption of a new heat-reactive varnish. The coil when baked with this varnish becomes a solid mass of great mechanical strength which fortifies it against short-circuit stresses. The varnish has remarkable penetrating qualities, extremely low acidity, and good oil resistance.



Distribution transformers, with cores of Hipersil, are easier to service; can carry high brief overloads.

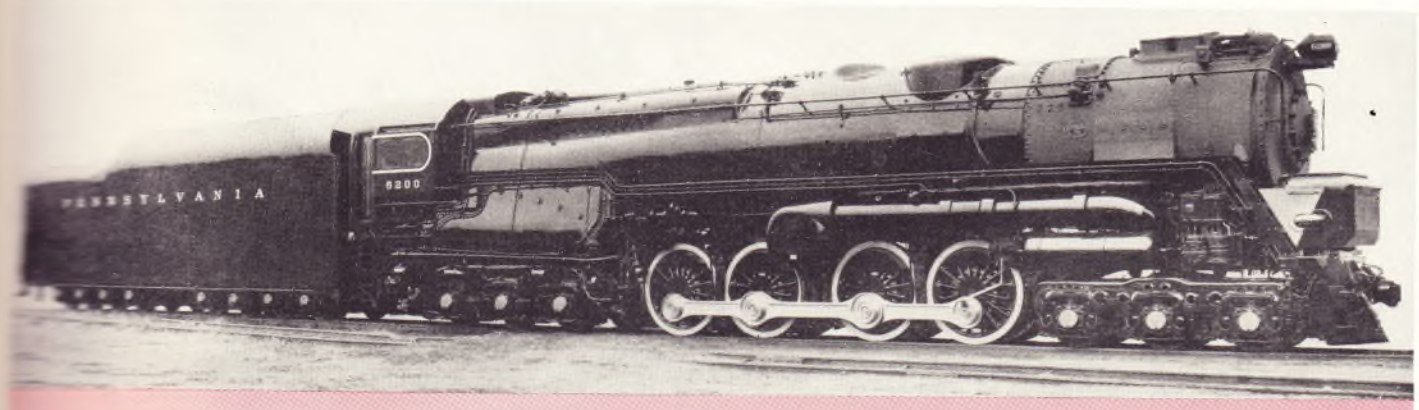
Convenience for the operator in handling these transformers has been furthered by providing the standard mountings, fittings, high- and low-voltage terminal connectors and all other details as specified by the EEI-NEMA distribution transformer standardization program.

A Locomotive with Geared-Turbine Drive

SOMETHING entirely new in locomotives is on the rails. It does not look radically different from an ordinary locomotive. It has, in fact, a conventional cab, boiler, tender, and wheel arrangement. But, missing are the cylinders, reversing gear, and main rods. Missing too is the familiar puff of a reciprocating engine, for it is not driven by pistons but by a steam turbine connected to the drivers by a double-reduction gear. It is a geared-turbine locomotive, the first ever built in this country, and is the product of the joint efforts of the Pennsylvania Railroad, the Baldwin Locomotive Works, and Westinghouse.

At this writing only test-track trials have been made—and these successfully—so that the performance and significance of this radically different railroad motive-power unit must await extensive main-line trials and dynamometer tests. However, the significant facts of the new locomotive are these. The boiler is standard, delivering steam at 310 pounds and 750 degrees, which is common for modern locomotives. The turbine design follows experience gained in the marine industry. It has six stages and is set above the second and third drivers of the four pairs of driving wheels. The 6900 horsepower, maximum, is delivered to two axles by a double-reduction gear. A single-stage turbine for reverse operation is on the left-hand side just opposite the main turbine and is connected to the ahead pinion through a clutch. The locomotive is intended for main-line passenger or high-speed freight service with a maximum speed of 100 mph.

Two main objectives are sought with this new type of drive. Because the turbine is more efficient than a reciprocating engine, this locomotive should provide one-fifth more power from a given amount of steam. This saves fuel, but of more importance in railroading is an increase of power from a locomotive of given dimensions. The turbine drive also eliminates the unbalanced forces inherent with reciprocating engines.



The first locomotive driven by a geared steam turbine, built in this country, has successfully completed its initial trials.

Special Signal Searchlights Aid Invasions

DURING those critical moments when landing craft are attempting their beaching mission on an enemy-held shore, communication between vessel and those already ashore, and between vessels themselves, is a must. Much of this has to be done with signaling lights. For this purpose engineers have fashioned a new kind of signaling searchlight as carefully tailored for this new kind of amphibious warfare as the LST's and LCI's themselves.

It is a miniature signaling searchlight. It is only eight inches in diameter instead of the usual 12 or 18, but has a range of a mile under all conditions under which landings are attempted. A venetian-blind shutter permits signaling twice as rapidly as flashing the lamp on and off with the inevitable wait for the filament to cool between flashes. The lamp has louvers for ventilation, yet they are arranged so the unit is wholly light-tight. With the lamp lighted and the shutter closed the unit is as black as the proverbial inside of a hat. The excellent light efficiency comes from the use of lamps of the sealed-beam type originally developed for automobiles. Because the reflector is inside the lamp, dulling of reflector surface by corrosion is no problem. Any of three types of lamps can be used without alteration of unit or wiring. These are 300 watts, 115 volts; 150 watts, 24 volts; and 100 watts, 12 volts. Hence the searchlight can be used on almost any kind of power supply, which in landing operations is usually limited in amount.

Mobile Lighting Unit Is a Quick-Change Artist

ONE of the most remarkable lighting units produced during this war is one, like the commandoes, always ready for any emergency. It is a 24-inch mobile light that, for the first time in a single unit, combines many functions such as an airport beacon, either rotating or non-rotating, a searchlight, a floodlight, a temporary lighthouse, or a signaling searchlight. Furthermore, to conform to the exigencies of modern warfare, it can be disassembled into pieces readily carried and reassembled with only fingers as tools. It can even be delivered by parachute and assembled in a few minutes under adverse conditions. One or more can be mounted on a truck equipped with generators driven from the truck engine through Davey Power Take-Off Units.

By using simple, snap-on type lenses, the beam can be made white, red, green, or yellow. The unit can be used stationary or rotated at any speed from one to thirteen rpm. The lamp can be flashed in any desired code combination. With a mask containing a 12-inch venetian-blind shutter (interchangeable with the one on the 12-inch searchlight) the unit can be transformed instantly into a signaling searchlight. Spread lenses can be fastened over the front of the unit to change the beam from a sharp pencil of rays to a floodlight with either a 10- or 40-degree spread. A spare lamp is fixed in position so that if one burns out, the spare automatically moves into position and carries on with almost no interruption.

The Reflector Lamp in Miniature

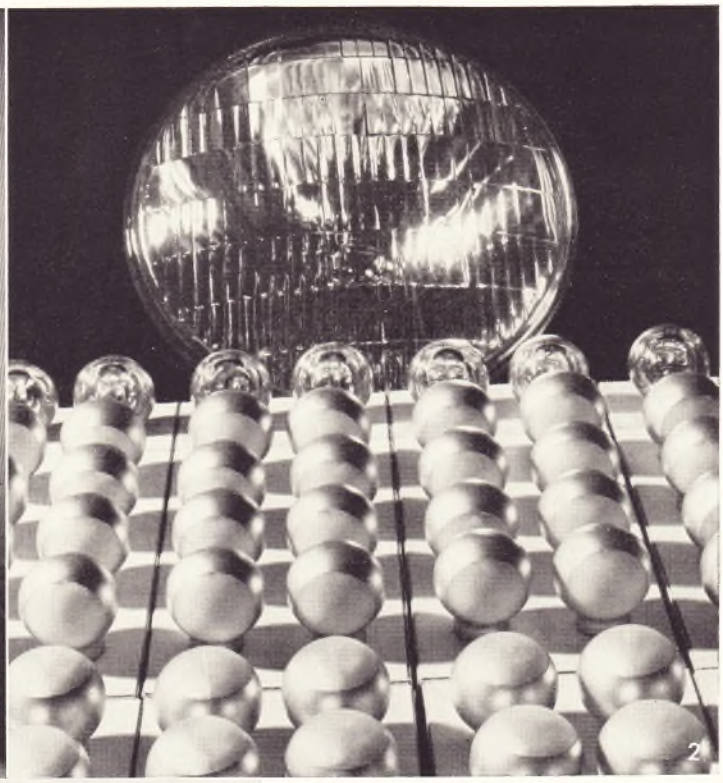
OUTSTANDING achievement in automobile lighting in the years just before the war was the sealed-beam headlight, which was a precision lamp and reflector incorporated in a single-glass envelope. The basic idea was to locate the filament precisely at the focal point of the parabolic reflector formed by a mirror-bright coating of vaporized aluminum on the inside of the rear half of the bulb itself. It proved to be a whale of a good idea. It spread quickly into a variety of forms for diverse functions such as airplane landing lights, reflector-type floodlights and spotlights. The idea now shows up in a form so different that all physical resemblance to the original sealed-beam lamp has disappeared.

It is a miniature lamp — miniature in size but giant in performance. Instead of being two parabolic halves, pressed together, the bulb is round, about the size of a large marble. The rear half or more of the bulb is "silvered," forming the reflector. The filament is placed with extreme accuracy in exact location with respect to the reflector to give the desired beam pattern. These "third-generation sealed beams" operate on various battery voltages. One member of the family, for example, operates from three dry cells and was designed to be part of the Army aviator's escape equipment by which he can signal his presence when forced into the sea. Another member is intended to be part of life-raft equipment and is supplied by a hand-cranked generator. Others are used by military forces in ways aimed to annoy the enemy.

These tiny six-watt lamps are designed to make the most light from the limited power available. One of them can project a beam of 1200 candlepower, which compares with the bare light intensity of a 750-watt general lighting lamp.

Simple Suns

MAN always has been a sun worshiper, to various degrees and in different ways. The sun beaches of the Riviera, the Florida and California coasts, and other famous shore spots outrank all others as vacation lures. Man has tried many devices to carry over the sun's health-giving qualities into his indoor life, particularly in winter. Cod-liver oil and the newer vitamin pills have been useful in that direction. Most desirable of all would be to duplicate the sun. Many types of sun lamps have been built, some of excellent quality, but usually

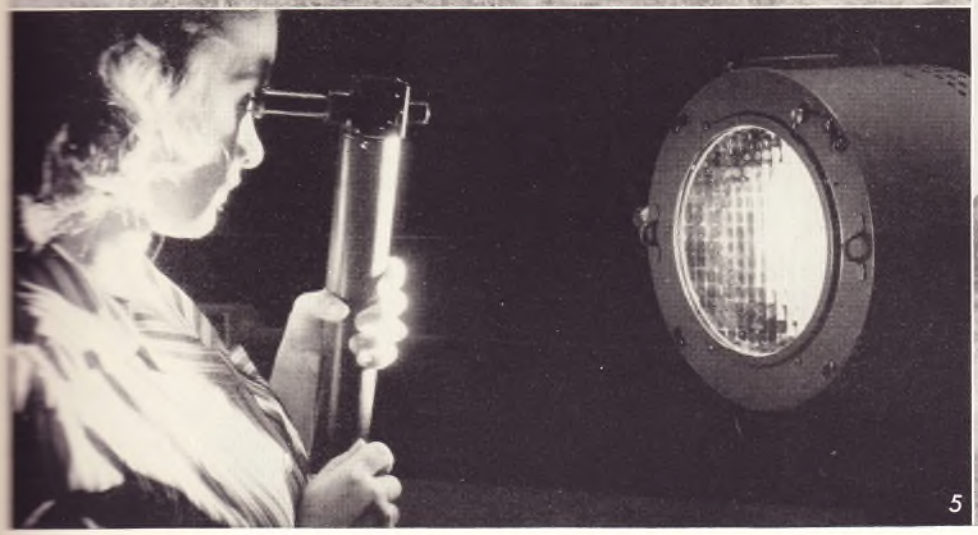


1—The simplicity of the self-contained sun lamp encourages more frequent use.

2—These miniature lamps with their built-in reflectors and precision filaments provide a variety of sharply defined beam patterns. They now have only military use but other uses are in prospect.

3 and 4—The 24-inch portable searchlight is unusually adaptable to the needs of a military force. It can be quickly taken apart or assembled without tools. A variety of snap-on lenses, shutters, and mountings permit it to be used as a rotating or stationary beacon, a searchlight, a code signaling light, or a floodlight.

5—The lady measures the beam intensity of the small but powerful 8-inch signaling light used on landing vessels.



limited in general application by their cost, bulk, or complexity of the accessory apparatus. The ultimate would be something as simple as an ordinary lamp bulb that can be screwed into any convenient lamp socket. Such indeed has been achieved. Availability of this new sun lamp had been announced in 1941, but it became one of the first casualties among civilian goods of the war, so that relatively few were made. Production is being resumed.

All bulb-type sun lamps depend for their ultraviolet radiation upon an electrical discharge through mercury vapor, and all electrical-discharge lamps require a ballast to regulate the flow of current. This has usually been a reactor or a high-reactance transformer mounted in the base of the sun-lamp stand. The possibility of using an incandescent tungsten filament as resistance ballast had often been considered. However, the difference between the high voltage necessary to start the discharge through mercury vapor between cold electrodes and the low voltage necessary to maintain the discharge once it was started was so great that either too large a portion of the total line voltage was consumed in the ballast, or it had to operate over such a wide temperature range that the filament life was short.

In effect the sun lamp has announced its independence of auxiliary ballast. It has solved the problem by taking the ballast inside with it. The lamp now consists of two bulbs, one inside the other and both made of ultraviolet transmitting glass. The inner one contains mercury vapor and is provided with two operating electrodes and a starting electrode. When in operation the inner mercury lamp provides the ultraviolet radiations while the incandescent tungsten ballasting filament in the outer bulb provides the visible and infrared heat radiations found in sunlight, thus serving a double function.

The bulb is not only a powerful generator of sun-like radiations, but also is its own reflector. Borrowing the sealed-beam principle first used with automobile headlights, the rear half of the bulb interior is coated with vaporized aluminum to provide an efficient reflecting surface.

The ultimate in sun-lamp simplicity has been achieved. It is no more complicated in form or use than an ordinary lamp bulb but does require care against overdosage.

More Light in the Beam

By a neat bit of shielding the beam, candlepower of a marine-type searchlight has been more than doubled. This is the 18-inch searchlight used on many Coast Guard and Merchant Marine vessels.

The problem in a searchlight is to convert the maximum amount of light into a sharp, narrow-angle pencil. A lamp sends out light in all directions, i.e., 360 spherical degrees. Utilization of light in only 145 of these spherical degrees has been about the best obtainable with marine-type searchlights because attempts to use more resulted in lack of sharpness of the beam, or light halo, which in fog is most undesirable. The new searchlight utilizes light throughout 290 degrees instead of 145 degrees. This and other measures to improve optical efficiency result in a beam candlepower of 2 225 000 instead of 1 085 000, or efficiency more than doubled.

The new so-called tandem-reflector system contributes to the large percentage of light utilization. Even the stray light caused by reflections from the inner walls of the lamp bulb itself is prevented from leaving the unit.

The new 18-inch searchlight has, in addition to the main reflector and clear front lens, an auxiliary reflector and spill shield. The auxiliary reflector in front of the lamp directs the outward rays of the lamp back to the main mirror and thence forward in the directed beam. The spill shield is a narrow band surrounding the lamp. It stops light that normally makes the edge of the light beam fuzzy. The area of the main mirror immediately behind the lamp is blackened to eliminate another troublesome source of spill light.

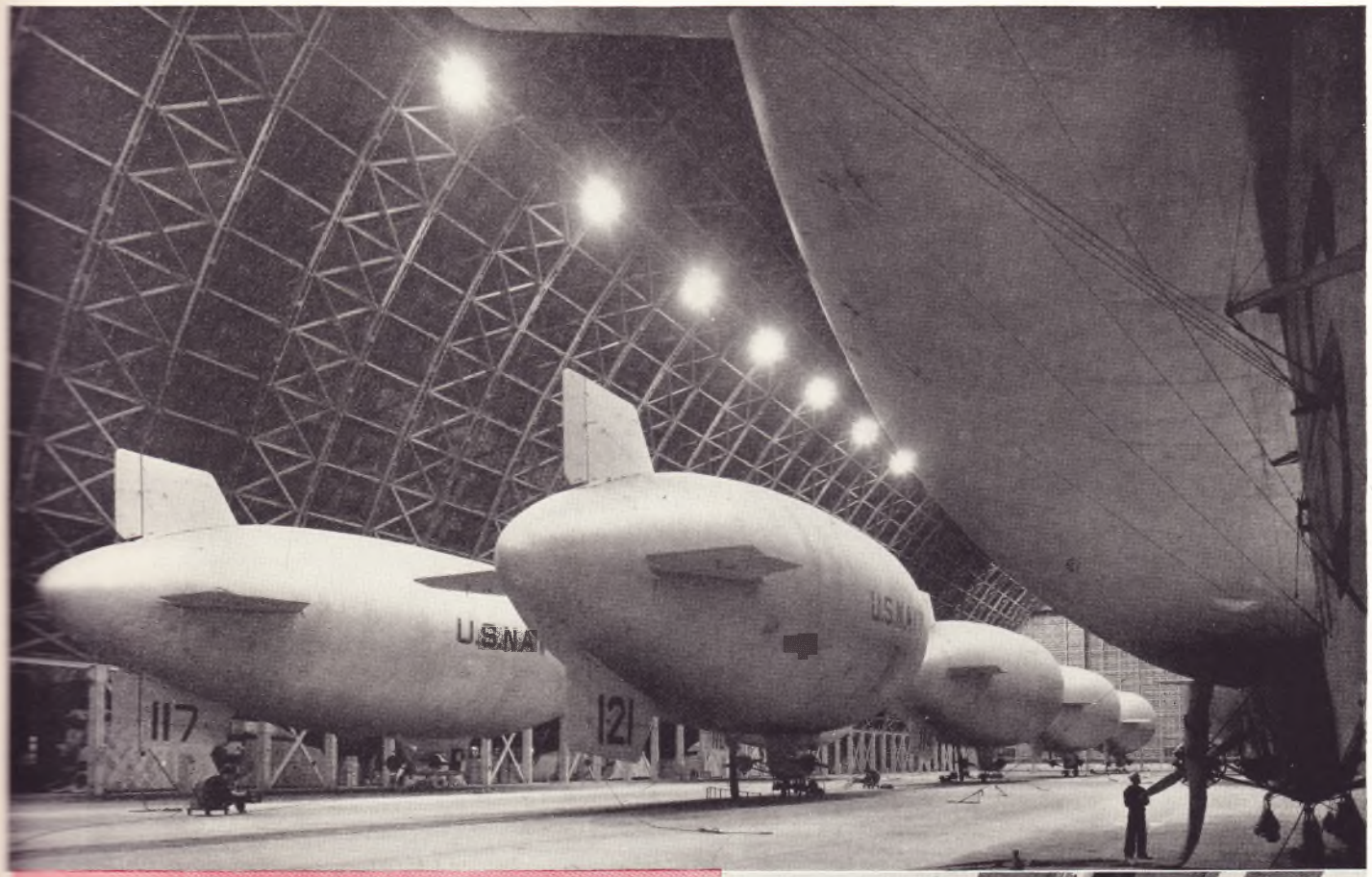
Coating Fluorescent Lamps Electrostatically

The electrostatic principle has been used with great success in the Precipitron to remove dust. It is now being used to deposit dust. Fluorescent lamps are being coated with phosphors in this manner.

The usual method of applying the coating to fluorescent tubes has been to flow a solvent carrying the phosphor dusts through the clear-glass tube — flow painting, so to speak. After the tubes have been flush painted in this fashion, they are dried and baked to remove all solvent.

In the new method, the glass tube is slipped over an ionizing wire and a high potential placed between wire and tube. A smoke of the dry phosphor is blown through the tube. The phosphor particles are ionized positively and are driven by the strong electrostatic field to the glass walls where they give up their charge and adhere firmly and permanently to the glass.

The electrostatic method has several advantages, both to the user and to the lamp maker. A gain of three to four percent in light efficiency is obtained. This results from the greater uniformity of



Where ceilings are high, as in blimp hangars, steel mills, and airplane factories, the new three-kilowatt mercury-vapor lamp is a great asset, because it can be mounted so high that its intensely-bright light source is not in the normal range of vision. Seven times larger than any previous air-cooled mercury lamp, it greatly reduces the number of units that have to be installed and serviced.

phosphor distribution. Electrostatic action lays the phosphors onto the glass with unparalleled evenness. The ionized dust particles strike the glass, release their charge, and immediately become insulating, leaving only uncovered areas to attract more dust. By the liquid-flow method, the coating at the lower or draining end of the tube is thicker than the upper end. To insure adequate covering at some sections the remainder of the tube must be too thickly coated for maximum light output.

Also, with the electrostatic method the tubes do not have to be treated at as high a temperature. This results in less phosphor deterioration by the baking. Tubes now do not have to be washed, as any clinging tiny dirt speck does not show. When the phosphor dusts are deposited electrostatically, the speck of dirt is covered evenly and does not affect the light. With the flow method, a small spot of dirt becomes an island and the eddies of fluid around it leave their mark. With the electrostatic method no liquids are involved. This eliminates the hazard attendant to volatile solvents and the inconvenience of liquids.

Electrostatic coating can be used for any shape lamp. For curved lamps the phosphor dusts are pre-ionized and blown into the empty tube.

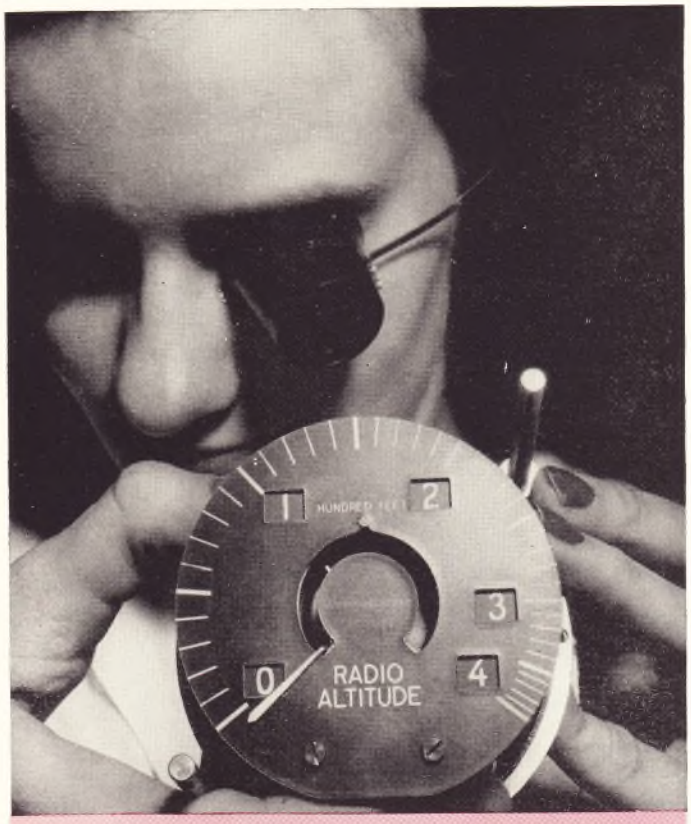
Electrostatic precipitation of phosphor dusts marks another step on the road to superior illuminants and another triumph for a most useful engineering principle.

An Absolute Altimeter—Victory for Flight

"How far is the plane above the ground? From a mountainside or other unseen obstacle?" These questions are uppermost in the mind of the pilot at night, during fogs and in storms. Answering them is a long forward step in flight safety. An absolute altimeter is now in mass production.

Unlike previous altimeters, which gave only an indication of altitude above sea level, the absolute altimeter provides information as to the distance to the nearest solid object, be it the ground beneath or a hillside or mountain. Furthermore, for distances within the all-important region of 10 to 400 feet it is accurate to within five feet of the actual distance.

The absolute altimeter, based on radio principles, is a development by engineers of several organizations, including RCA and the Navy. The system requires a special instrument developed by Westinghouse. It is a highly accurate d-c milliammeter of the circular-scale type and is fully temperature compensated to operate at temperatures from minus 67 to plus 18 degrees F. Over the normal range of temperature the accuracy is within one percent. The instrument has two scales, 0 to 400 feet, and 0 to 4000 feet, selected by turning an external switch. Only one scale shows at a time behind the dial-face window, eliminating any possibility of error by the pilot reading the wrong scale. The instrument, made as light as possible because of its use in airplanes, also combines the master control for the entire absolute-altimeter system.



One of the instruments that gives pilots an indication of the absolute distance to earth gets a careful examination

Gyroscopes Driven by A-C Motors

Gyroscopic devices have had a large place in the war from its start. Small panel-mounted instruments have used air gyroscopes driven by air or by a-c motors supplied from inverters, but most of the large gyros used in flight-control devices, bombsights, and similar computing devices have been powered by d-c motors. At the high speeds at which these high-inertia wheels turn (7500 to 20 000 rpm) motor-brush friction can cause precession errors, and brush dust may foul the bearings. Direct-current gyros are usually series-wound because of the high-inertia wheels and long starting time (sometimes one-half hour to reach full speed). As a result the speed increases considerably as air friction decreases at high altitudes.

For these reasons, a program is under way to develop a-c driven gyros for the more important applications. Granddaddy of the a-c gyro family is one with a rotor five inches in diameter operating at 12 000 rpm from a 400-cycle, three-phase supply. The angular momentum of this wheel, in the units used by gyro instrument engineers, is 83 500 000 gram-centimeters squared times radians per second.

Baby of the family is one $2\frac{3}{16}$ in. in diameter, which replaces an air-driven gyro in a computing sight. This gyro achieves a momentum of 38 800 gram-centimeters squared times radians per second.

Although "inside out" squirrel-cage motors are used for some of these gyros, most of them are "inside out" hysteresis motors. The usual rotor is part of the flywheel and rotates outside of the air gap, the polyphase stator being wound inside of the air gap.

Hysteresis motors require no squirrel cage, but instead employ discs of permanent-magnet steel for the rotor. Magnetic hysteresis caused by the rotating field causes the rotor to accelerate and finally fall into synchronism.

No Help for the Japs from the Sun

Japanese fliers are no longer so anxious to try one of their one-time favorite tricks. They liked to come roaring at one of our airplanes directly out of the sun, which made so bright a background that our gunners could not draw a bead on them with the illuminated sight. This stunt no longer works so well. Many Japanese have learned permanently that our pilots and gun crews can shoot with deadly accuracy even while looking almost directly into the sun.

Largely responsible for this feat is a new kind of gun-sight lamp, which provides from 8 to 30 times more illumination from the same energy input than lamps available earlier in the war. Details of lamp construction are still withheld, but its performance is no secret. It illuminates the reticule pattern—a small dot or bull's-eye surrounded by two circles which the gunner superimposes on his target—with such intensity that even with the sun as a background the pattern is not washed out or lost in the glare. The limiting factor in sighting now becomes the amount of light the gunner's eyes can take, not the relative intensity of the sighting pattern.

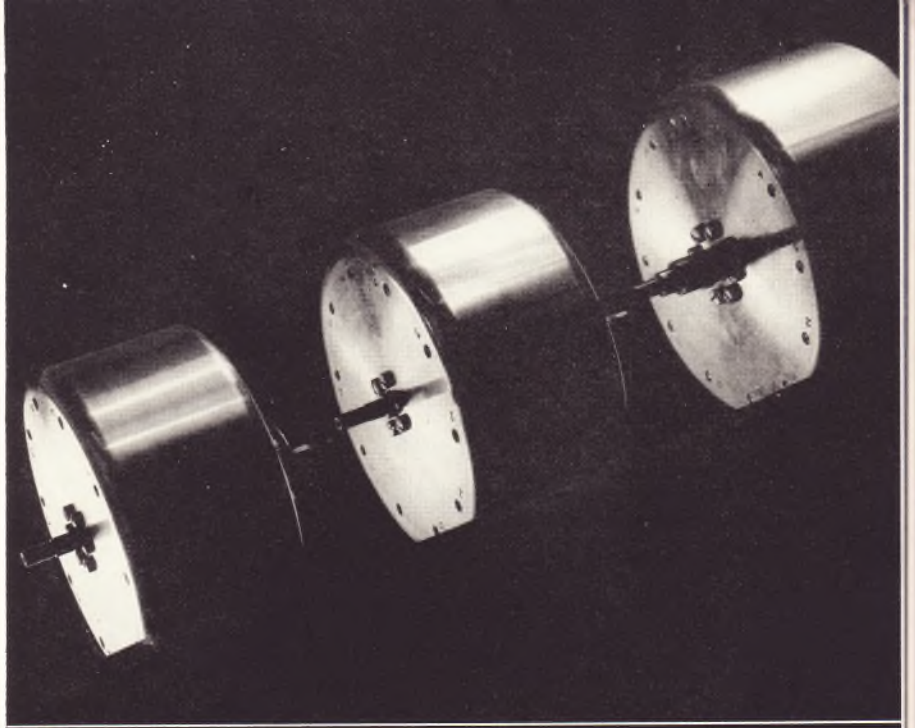
The new gun-sight lamp is also arranged so that at night, when a bright reticule pattern would be blinding to dark-accustomed eyes, it can be dimmed to any desired intensity.

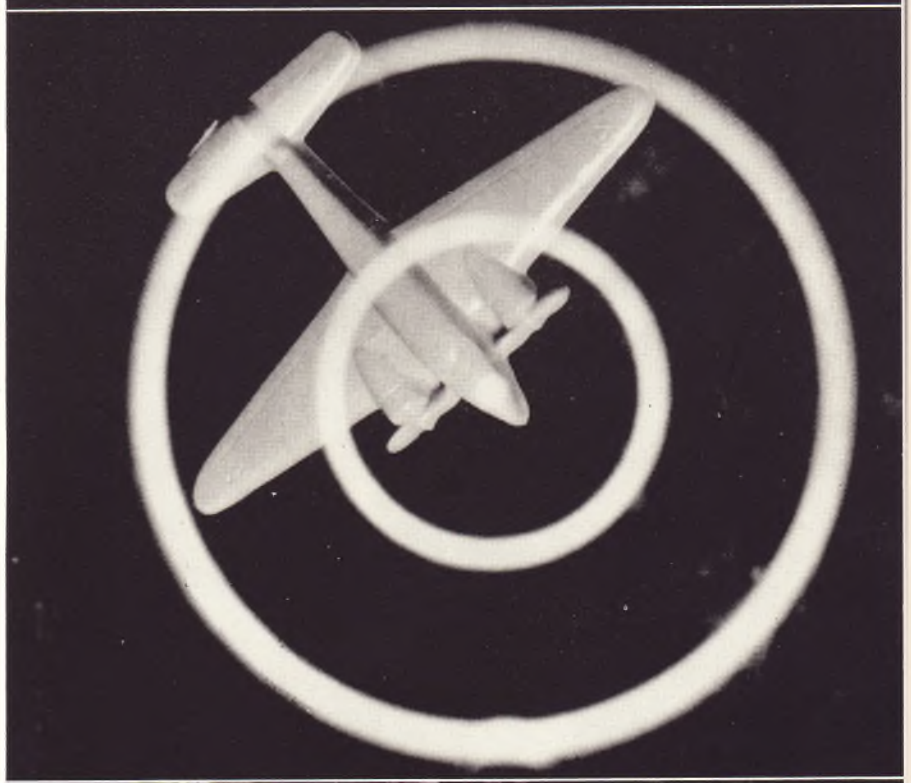
Flying Generators

NEARLY one million kw in Westinghouse generating plants have taken to the air since Pearl Harbor. Mostly they have been of the Army Air Forces P-1 type. Such generators are used on the Flying Fortresses and Liberators. Through research, metallurgical development, and engineering design the life of these 5.7-kw, 44-pound machines has been doubled each year since the first ones were built. This 200-ampere, 2500–4500-rpm generator now has several companions, comprising a family of generators for all types of airplanes, military, commercial, and private. A small member of the group is a 100-ampere, 30-volt unit for high-speed operation (4000/10 000 rpm). For the planes that will use the a-c system, a 6000-rpm 40-kva generator with built-in exciter and weighing only 85 pounds is ready.

A-C Systems for Airplanes

AT WRIGHT FIELD, near Dayton, during the closing weeks of 1944, engineers were busy getting ready to fly a service airplane "on the ground." The labors of design engineers over a period of many months to produce the numerous components required for the much-discussed 400-cycle alternating-current power system for the giant planes of tomorrow are bearing fruit. Because the individual operation of each generator, motor, switch and relay is affected by the operation of all members of a group, it is desirable to test the system as a whole on the ground before putting it in the air. For this reason the Army Air Forces has established a complete electrical mock-up of a multi-engine plane on which the various components of the a-c system can be tested as they are provided by the various manufacturers. For this mock-up the engines have been set up on stands. Provision is made for the





(Top view) Gyroscopes, with their mirror-polished inertia wheels, are machines of extremely accurate balance and great precision. (Center view) Here is a gunner's eye view of a target as seen through a gunsight with its reticule lighted by a greatly improved gunsight lamp. (Bottom view) Generators are given run-in tests of several hours, in addition to various electrical tests. These generators, mounted atop the driving motors, are the famous P-1, in service on all fighting fronts.

driving of the 40-kva alternating-current generators, which are already available, through gears or through various hydraulic constant-speed drives as they are perfected. The mock-up further includes the wiring and controls laid out much as in the airplanes and to them are connected many of the actual a-c motors, motor-generator sets, radio, and other loads. From a control stand the flight engineer's controls are simulated so the plane can be "flown" while all elements of the electrical system are under close observation and measurement. In addition to checking the performance of the generators, synchronizing apparatus, regulators, circuit breakers, and motor-generator sets, all newly designed for 208-volt, 400-cycle operation, the study is probing such questions as whether automatic synchronizing is necessary, sharing of both

Generators, motors and dozens of special electric controls and mechanisms are essential on every plane. (U.S. Army Air Forces Photo)

real and reactive loads, the rapidity with which short-circuits must be cleared to avoid motor stalling, coordination of protective devices during a fault condition, and many others.

The essential elements of the new a-c systems for planes are fast assuming physical form. The on-the-ground testing of the elements combined into a single system marks another step in the progress to a successful a-c system.

Engine Output Measured by Shaft Twist

CONSIDER the problem of operating one to six remote power plants of several thousand total horsepower to best advantage without direct indication of the power each engine delivers to its load. In any land practice this would be unthinkable. In aircraft it is routine.

No entirely satisfactory scheme has been available for informing the pilot how much power each engine is delivering to its propeller. Now the slight twist in the shaft carrying the power to the propeller provides the meager but ample clue from which the engine load is determined accurately. With this system the pilot has before him a continuous indication on direct reading instruments of the torque output of each engine (i.e., rpm from the tachometers and torque from the torque meters), which enables him to control the several variables—propeller pitch, engine speed, carburetor manifold pressure, etc.—for maximum fuel economy, and economy means miles.

The device that provides the heretofore missing torque complement and makes this possible is based on the principle of the magnetic strain gauge. On a section of the shaft between reduction gear and propeller are located three collars magnetically isolated from the shaft. They are notched and mated in such a way as to provide between them many air gaps, a few thousandths of an inch each. These collars with their air gaps revolve with the shaft inside a stationary member containing windings carrying a small 400-cycle current. The magnetic circuit consists of the stationary member, the air gaps to the rotating member, and the three rotating collars with their multiple air gaps. As the shaft twists a minute amount under load, one set of the multiple gaps widens and the other set narrows. The electric circuit is such that the result of this action is to increase the impedance in one leg of a bridge circuit and to decrease it in the other. This unbalances the bridge, causing a proportional current through a milliammeter, calibrated in torque units, inserted across the bridge. The proportionality holds throughout; the torque and the current are both proportional to the change in the gap distances. The maximum bridge output for any engine is 1.5 milliamperes, which is sufficient to operate the instrument full scale without amplification.

Aircraft torque meters have been built in two forms, one for installation on the propeller shaft extension, when space permits, the other for use inside the engine gear case for close-coupled propellers. The two types of torque meters, however, differ only in form, not in principle.

To provide the small amount of power required by a pair of

torque meters, a special motor-generator set has been built. A d-c motor drives a special 6-pole magneto-alternator generator at 8000 rpm to produce 75 volt-amperes at 400 cycles. The generator is two phase, each 37.5-volt-ampere phase serving a separate torque meter. The generator rotor is unusual in that it has a rotating field structure with no windings. The rotor is a permanent magnet consisting simply of a smooth, alloy cylinder magnetized to give six radial poles.

For **Exact Stopping of Airplane Motors**

A DIRECT-CURRENT motor turning at 16 000 rpm is stopped in 1/15 second. The armature turns but 11 revolutions after the brake is applied. This is done by a new kind of electromagnetically controlled friction brake that operates without disengaging the motor rotor from the load. A disc of special friction material, splined to the shaft, turns between two stationary brake shoes that try to close under spring pressure but are held away by electromagnetic coils as long as power is applied to the motor. Opening the line switch allows the springs to force the shoes against the spinning brake disc and affords virtual instantaneous stopping. This system is much simpler mechanically than one in which the rotor is first disconnected by a clutch. By applying pressure equally to both sides of the shoe, end-thrust effect on the motor bearing caused by braking is reduced to an inconsequential figure. The brake, although the essence of simplicity, was still operable after a test run of 10 000 operations. For use on a special propeller-feathering motor, one of these brakes had to withstand an ambient temperature of 200 degrees F, and a vibration of 50 times gravity imposed 240 times per second for 50 hours.

Brakes of this sort are sorely needed on many motor-driven devices aboard airplanes to permit more exact operation of distant controls or to prevent injury to the motor or the device resulting from jamming against mechanical stops caused by motor momentum.

Airplane **Voltage Relays That Won't Chatter**

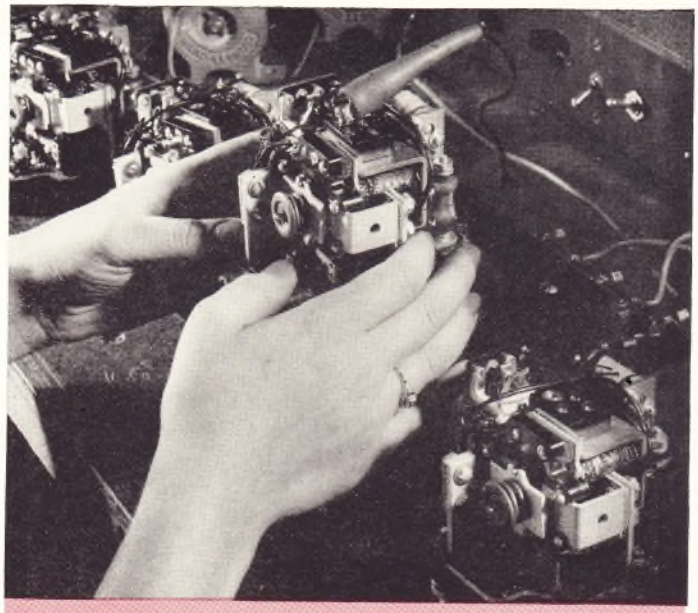
A NEW KIND of relay that is able to measure two voltages and subtract one from the other and acts according to the arithmetic result produces a great improvement in the operation of multi-generator, direct-current systems aboard airplanes. With the conventional reverse-current relay and cutout system, a direct-current generator on an airplane is disconnected from the power system if instead of delivering current it drew current from the battery or another generator, thus acting futilely to drive the engine faster. The cutout, on the other hand, reconnected the generator to the system when its generated voltage was above a fixed amount. Under this system, with two or more generators in parallel at light load, conditions are possible under which the reverse-current relay disconnects a generator only to have the cutout reconnect it, and so on indefinitely. This sometimes happens with such rapidity that the relay chatters and the life of the contacts may be shortened to a few hours.

The new device is called a differential relay because it connects the generator to the power-supply circuit only when its voltage is above the circuit voltage by a certain amount, i.e., only when power can flow out of the generator into the circuit. This stops chattering. Also it does other things. It makes it possible to generate power anytime the generator voltage is higher than battery voltage, although both may be low as would be the case on a long return flight made at low engine speed to save fuel. With the old system, the generators cannot

A quick-acting brake lies beside a d-c motor for airplane service. The brake fits inside the motor housing.

be used to assist the battery under such conditions, because the generator voltage is below the fixed amount for which the cutout is calibrated.

Although the relay cannot function as a circuit breaker, it protects the system against reverse currents resulting from generator short circuits. On test it has interrupted 3500 amperes at the equivalent of 50 000 feet altitude. Like conventional polarized relays, it makes it impossible for a generator to be connected to the system if its polarity is reversed.



These relays allow the airplane generators to be connected to the airplane electrical system when, but only when, power will flow from the generators to the battery or the circuit.

Marine

Super Ice Breakers Have New Tricks for Heavy Ice

PERPETUAL enemy of the Coast Guard, in war or peace, is ice. Every fall, winter, and spring the Coast Guard battles the ice in the Great Lakes, our northern harbors, and in the sea lanes to keep ships moving or to shorten the grip of winter on shipping. Many famous, specially-built ice-breaker ships have taken part in this ceaseless struggle. Added to these vessels are several new ones, more powerful than any ever before built, ships that include new offensive weapons for operation against Old Man Winter's defenses.

Most spectacular feature of these new ice breakers is a propeller in the bow of the vessel, in addition to two conventional stern propellers. The bow propeller, driven by a 3300-shp d-c motor can turn in either direction, i.e., in the reverse direction to build-up a bow wave to assist in cracking heavy ice or in the forward direction to pull water out from under the ice allowing the ice to break under its own weight. The bow propeller can be operated in either manner as proves most effective under different ice conditions.

Each of the stern propellers is driven by a 5000-hp motor, the total being 1500 hp more than on the highest powered Victory ships. Power for these two stern propellers and the bow propeller is provided by six 1375-kw diesel-driven generators in three engine rooms separated by water-tight bulkheads. Power plant for the bow propeller is forward.

In normal, free-running service, which is by far the greater part of the time, the speed of each motor must be increased from the ice-breaking speed of 105 rpm to free-running speed at 145 rpm in order to utilize the 5000 hp available to the propeller. This is accomplished by an automatic current regulator in the motor field windings, which cause the motors to absorb practically full output of the diesel engines at all times.

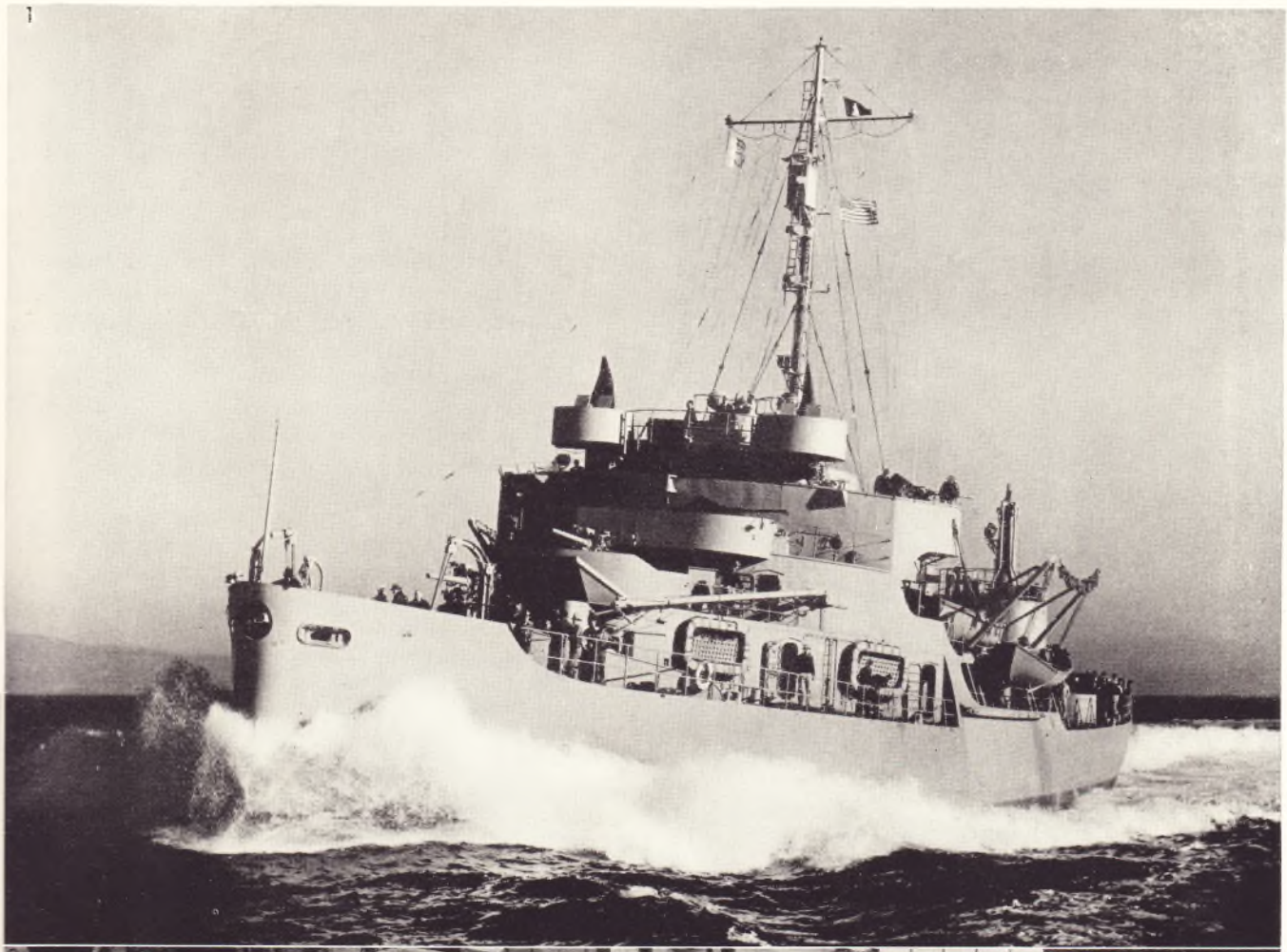
For these new ice breakers, however, the generators are operated in parallel, using one, two, or three units as necessary. Speed of the propulsion motors is controlled by gradually raising the generator excitation to approximately 75 percent of maximum excitation, while the engines are running at a minimum speed and the motors are excited at a minimum value. Higher speeds are obtained by raising the engine speed gradually from minimum to maximum speed, while at the same time the generator excitation is increased from 75 percent to normal value. During this period, the motor field is under the control of an automatic current regulator, which causes the motors to absorb approximately the maximum available engine output at any speed and loading condition. This provides maximum efficiency.

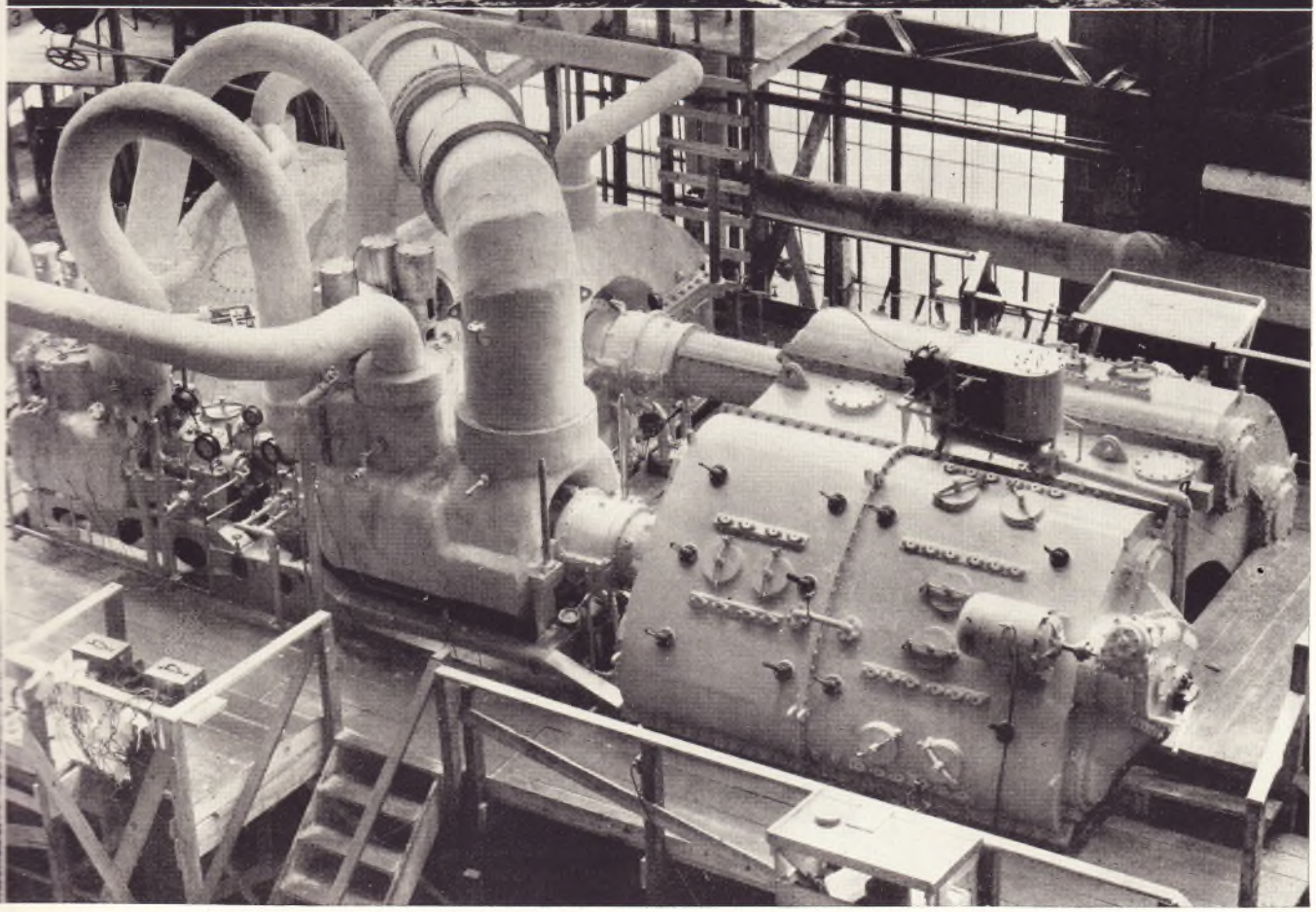
Under ice-breaking conditions a torque-limiting governor prevents damage to the equipment from overloading by automatically reducing the engine speed, which is followed by a reduction in motor speed and load. The overall result of the engine, motor, and control system is the availability of full horsepower over a wide range of propeller speeds from several generators in parallel and delivered at high efficiency.

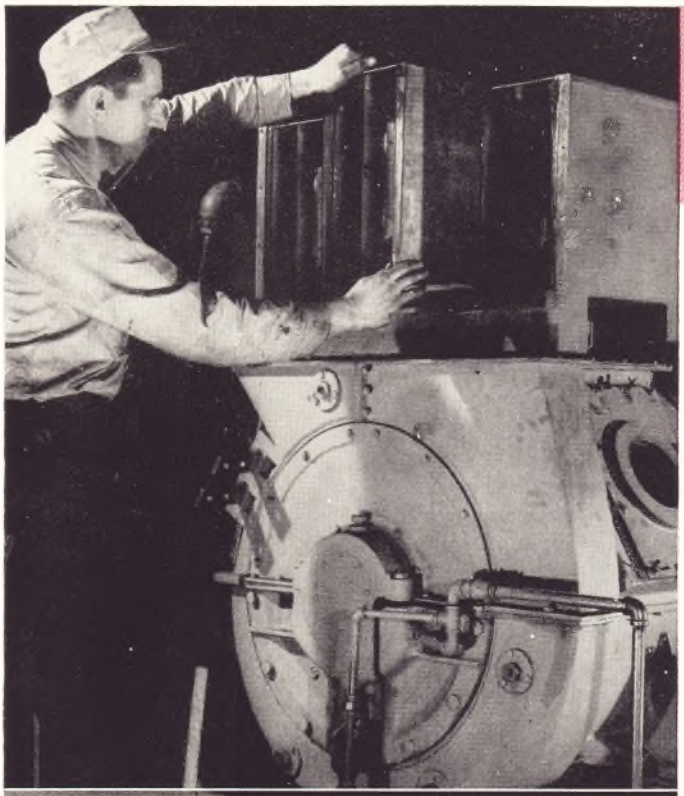
1—The Coast G… most powerful ice… addition to two … pellers, a 3300-h… (Official U. S. C…

2—With sleek li… powerful propuls… put into vessels, … Iowa class combine… This 45 000-ton … four geared turbi… more than 50 00… power for the hu… services, each ba… iliary power pla… driven generato… sizable electrical …

3—Each of the m… class aircraft ca… four sets of ge… this, all built by W… unit consists of a … a low-pressure tu… bined horsepowe… propeller throug… gears. A highly-e… capable of drivin… at high speed. (U…







Aboard ship, for example, ventilating air for motors cannot be changed frequently because brush dust, mixed with the oil vapor usually present, may gather on the windings and impair insulation strength. The Precipitron—the electrostatic air cleaner—is being used in machine ventilating systems to trap this dust. In this auxiliary generator the Precipitron is built into the frame structure.

Steam-Driven Forced-Draft Blowers

A DESIGNER of merchant ships that must enter combat areas must be a strategist also. Like a good general or admiral, he must anticipate and strengthen or eliminate vulnerable points. A ship without a blower to force a draft of air into the furnaces is vitally impaired. With a motor-driven blower a mishap to the electrical system would cause the ship to flounder, placing it perhaps at the mercy of the enemy. In normal times, the hazard of outage does not outweigh the advantages of efficiency and simplicity of the electric motor, but in wartime it's different. To eliminate this vulnerable link in the ship's power plant, a new type of steam-driven blower has been developed, especially suitable for cargo-ship service. It is of the same basic type of blower long used on fighting vessels, but stripped of many features made necessary by the more rigorous Navy service. The blower, for example, has no speed-limiting governor. The speed of the turbine is limited by the blower, which provides a load that rises as a cube with speed, hence runaway is impossible. The new blower foregoes a separate oil cooler, and hence needs no water connections. The blower is built for vertical operation. By placing both bearings below the turbine element, i.e., by overhanging the single stage of blading and the blower, only one steam gland is required. This also makes it possible to lift out the entire rotating element with the bearings as a unit assembly.

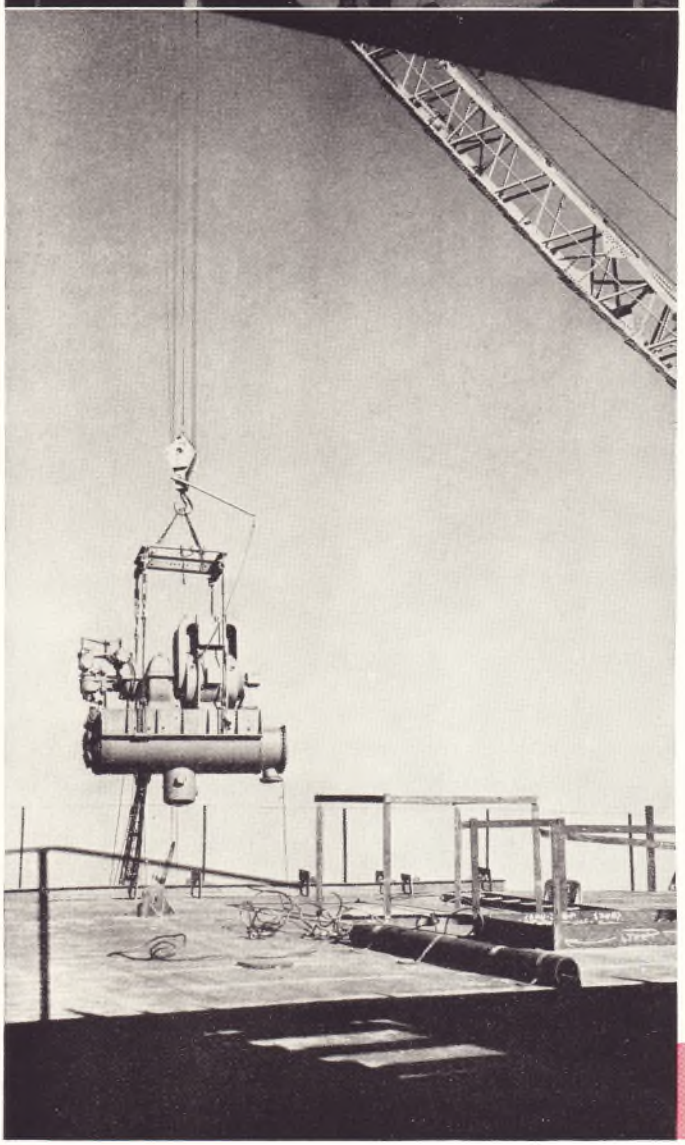
The steam-driven blower provides for wartime shipping conditions the utmost in reliability, a wide range of speed control, and ease of starting with low steam pressure.

Package Power Plants for Troopships

THE troopships and cargo transports that will have a signal part in ringing down the curtain on the Japanese have a rather remarkable type of main power plant. The 3500-shp turbine, generator, and condenser comprise a single "package" that can be lowered into the engine room as one unit. The package is truly complete, even to the lubricating oil system, pumps, piping, etc. Only connections to the steam and water line and electrical connections need be made.

These new ships are twin screw, each shaft being turned by a 3300-hp slow-speed synchronous motor and supplied with energy by one of the "package" power plants. Contributing to the small bulk of the power unit is the high speed, 4800 rpm, which means an 80-cycle electrical system.

The excitation for the generators instead of being governed by the usual type of regulator is under the control of a rotating regulator of the Rototrol type. This permits smaller normal excitation power (and excitation equipment) but provides a rapid boosting of excitation in emergencies, as during the increases in load that may develop in shallow water or in heavy storms. This system provides an automatic control of stability of the a-c motors and generators.



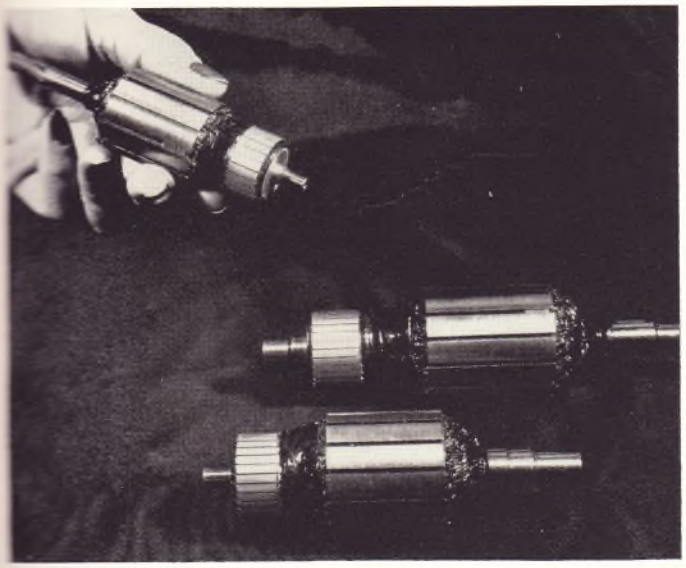
A complete 3500-shp power plant is lowered as a unit into a cargo transport. (Photo courtesy of Walsh-Kaiser Inc., Providence.)

Electricity at Work

Longer Life at High Speed

Like building automobiles for racing, the problem of the high-speed tool-motor builder is to make a seemingly small improvement here, a slight modification there, which accumulate to an overall improvement in the strenuous service intended. Motors for small size drills, grinders, routers, and other tools are of the universal type and run at 8000 or 10 000 rpm fully loaded. When the load is removed, the speed jumps to 20 000 rpm, which imposes severe centrifugal stresses on the rotating parts. In such use motors may last only a few hours or a few hundred hours depending on the severity of service, which varies widely.

The life of such motors has been greatly extended without making any basic changes by re-examination of every tiny detail of their design and construction. For example, a new



These tiny armatures used in high-speed tools must withstand the stresses of sudden changes in speed from 10 000 to 20 000 rpm.

thermosetting high-temperature varnish provides a durable, moisture-resistant surface that is extremely resistant to vibration. Although the armature is machine wound, each turn of each coil is shaped as it is placed in position instead of shaping the turns as a group. Assembled commutators are first spun at high speed to disclose any mechanical defects before they are placed on the armature.

Just as many of the lessons learned in racing were embodied in stock cars, many developments that grew out of attempting to improve high-speed motors have already been applied to the common garden variety of universal motor used in blowers, vacuum cleaners, and many prosaic jobs.

Civvies for High-Current Welders

The war called into existence many 1000-ampere alternating-current welding sets for use with automatic machines in fabricating large, thick-plate war equipment. A novel bit of engineering makes it possible to convert these machines for manual service should slackening war work decrease the need for so much automatic welding. It is a sort of welder-conversion device. With it the welder can serve as a power supply simultaneously to six individual, manual welding operations.

The device consists primarily of a transformer and a group of six reactors, which are fed by the welding transformer. The transformer steps the normal operating open-circuit voltage down from 85 volts to 75 volts, which is more suitable for manual welding, increases the amperes available for welding. The output of any of the six groups of reactors is controlled by placing two bayonet plugs in one of 20 possible settings, which provides a current adjustment over the range of 45 to 270 amperes in approximately equal increments.

So That Arc Welders Can See

An arc welder before he strikes his arc is as blind as the proverbial bat. That man-from-Mars mask he wears has a window of smoked glass that cuts out 98 percent of the light. Objects under normal illumination cannot be distinguished through it, although the arc creates a light so intense that the welder can see the work even through the dark glass. But he needs to see just where to touch his electrode to start the weld and do it accurately. Heretofore welders have had to develop a sort of sixth sense of position, which is all very well but is not conducive to best-quality work. A new spotlight takes out this guesswork by casting on the work area a light of 10 000 foot candles, which is twice as bright as the brightest sunlight on a seashore in summertime. This light from a 32-watt, 8-volt lamp of the sealed-beam type is intense enough for the welder to see the spot to be welded even through his mask filter. A foot switch makes it possible to turn the light on for an instant to locate the spot where the arc should be struck. This unit is still a laboratory development and is not commercially available.

Ridding a Factory of Mosquitoes

AT YOUR summer resort, mosquitoes may be but an annoyance. In the tropics they mean transmission of the dread malaria. In a war plant located in a swampy neighborhood, as along tidal waters, they may lead to work stoppages, absenteeism, slower production rates, and ruined material. Certainly their tantalizing whine does not promote good dispositions among workers under the stress of war production. With this problem before them engineers and health authorities at the Merchant Marine Plant of the Westinghouse Company, located on low ground adjoining the tidal Delaware River, declared war on mosquitoes.

The anti-mosquito patrol at work. This portable unit dispenses an insecticide as a fine mist in a turbine-manufacturing plant to end a serious nuisance delaying war work.

Before they could kill 'em they first had to count 'em. To do this, mechanical counters for mosquitoes were designed, a device using a blower to draw in known quantities of air every hour. The air passed through a cone-shaped screen that caught the mosquitoes and directed them into a cyanide chamber for killing and periodic counting. With several of these counters outdoors and others indoors it was easy to make a comparison of the numbers of the pests outside and within the plant.

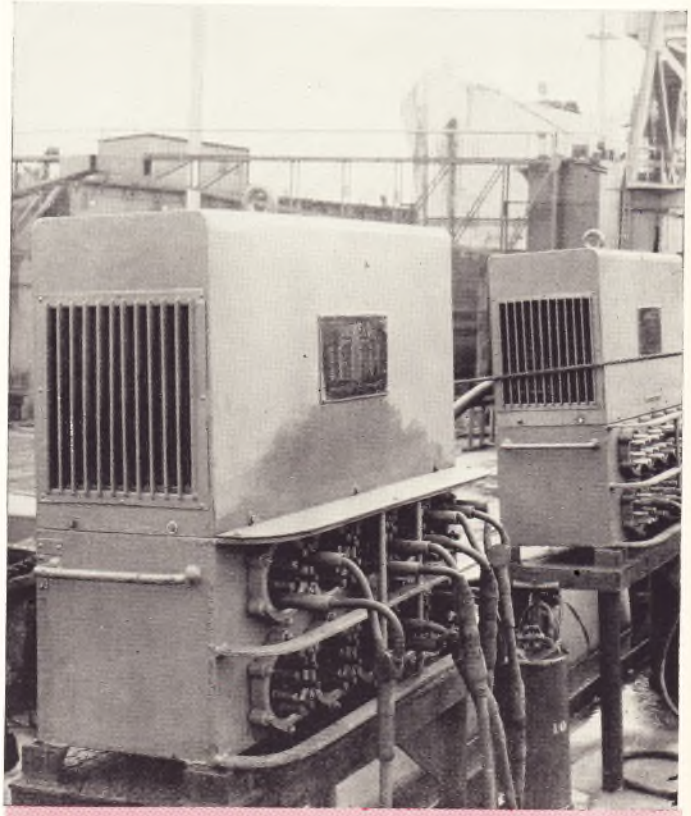
The means of killing the mosquitoes in the 27 000 000-cubic-foot plant consisted of a portable aerosol dispenser. This unit was wheeled on a regular route throughout the aisles in the plant to cover every cubic foot of space. Its gasoline-engine driven blower dispelled a cloud of insecticide consisting of the now famous DDT mixed with solvents and a dispersing agent. Because of the fineness of the droplet particle, the insecticide hung in the air and infiltrated to every part of the factory where mosquitoes could possibly hide.

This mosquito control in large confined spaces is being conducted on an experimental basis under the general supervision of the Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture, in cooperation with the Labor-Management Production Committee at the Merchant Marine Plant and the Headquarters Medical Department. Much is being learned about the habits and characteristics of mosquitoes. Such data include the effect of different elements of the weather on the mosquito population and the rate of migration; the lag between peak population outside and the peak inside; and when, with respect to outside conditions, the admission of aerosol is most effective.

Resistors for Multiple-Operator Welders

MANY large welding operations, such as shipbuilding require multiple-operator welding supplied from a central plant furnishing welding power at constant potential. Heretofore, this has entailed the use of large air-cooled resistances to enable each operator to have his own current adjustment. These bulky equipments for each welding station posed a traffic problem in restricted welding areas and required a means of moving much large equipment as the work progressed. A new multi-weld panel has liquid-cooled resistances and provides ten outlets in one compact unit. All of these outlets can be used at once and each operator can change his current values at will without disturbing the nine others.

The resistances are enclosed in a tank filled with Inerteen (a noninflammable safety coolant). The cooling medium circulates by convection through two radiators each cooled by air blast from a motor-driven fan. The equipment is protected by a thermally tripped breaker. The fans start as soon as the main breaker is closed and continue to run until the breaker handle is moved to the reset position, even though the breaker may have been tripped electrically.



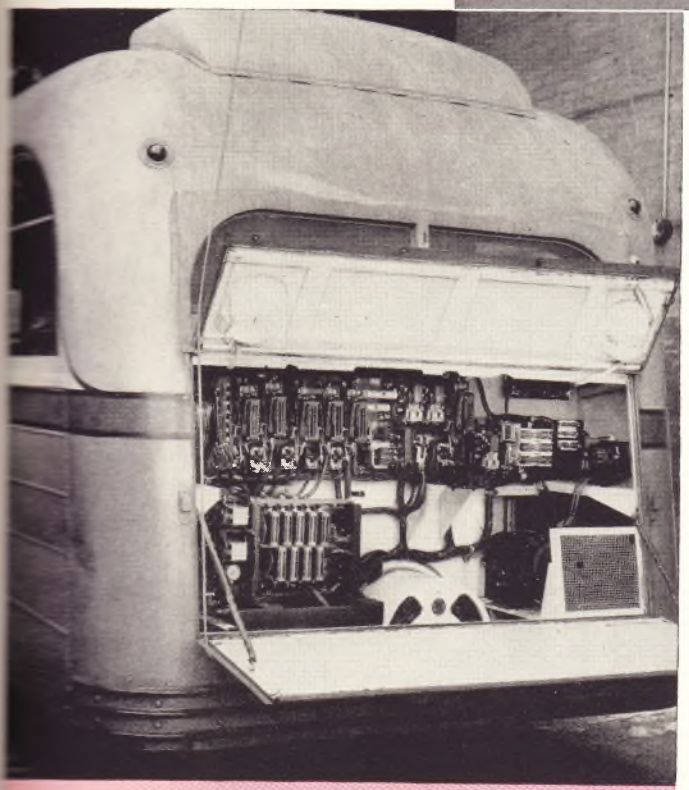
In shipyards such as this the new liquid-cooled resistors enable 10 welders, working from a common constant potential source, to have the necessary individual current control.

For Better Trolley Coaches

THE trolley coach, youngest of all city transit vehicles and the one growing most rapidly in popularity, is the recipient of a raft of improvements in its control and drive. The result is better performance, as viewed either by the rider or the operator.

The new coaches have new-type controls. Heretofore the coach operator, in the front of the vehicle, controlled the master switch, accelerator, and reverser, which are in the back of the coach, by three long mechanical linkages. These are subject to wear and possible mis-operation. Now the controls are all operated electrically. All 12-volt instead of 600-volt control circuits are used. This means the control coils are wound with heavy and more rugged wire and the space factor is increased by the lighter insulation. Cam switches replace the more complex and less positive interlocked sequence switches. Dynamic braking has been extended down to about two miles per hour from about four, with consequent less wear of the mechanical brakes.

Trolley-coach motors have been self-ventilated by a fan on the shaft. Because the speed of the motor fan varies from zero to high speed, the motor receives no cooling effect at standstill, only a little while the coach is pulling slowly up a heavy grade, and more than necessary at high speed (which is a power waste).



By providing the trolley coach motor with air from a separate fan instead of its own the motor runs cooler and more of the waste heat can be used to heat the coach interior.

The new trolley-coach motor has no fan of its own. The separate motor-driven fan used to ventilate the resistors and control has been made a little bigger, from 1½ to 2 hp. It blows a draft of air first through the motor, then across the resistors, and, in winter, into the coach for heating. Previously the motor heat was thrown away. Power is saved, the coach is better heated, and the motor runs cooler.

Testing Motors at 30 000 Rpm

SOME engineering developments move forward so rapidly they outstrip the means for testing or checking them. Such has been the case with small, very high-speed motors. Under

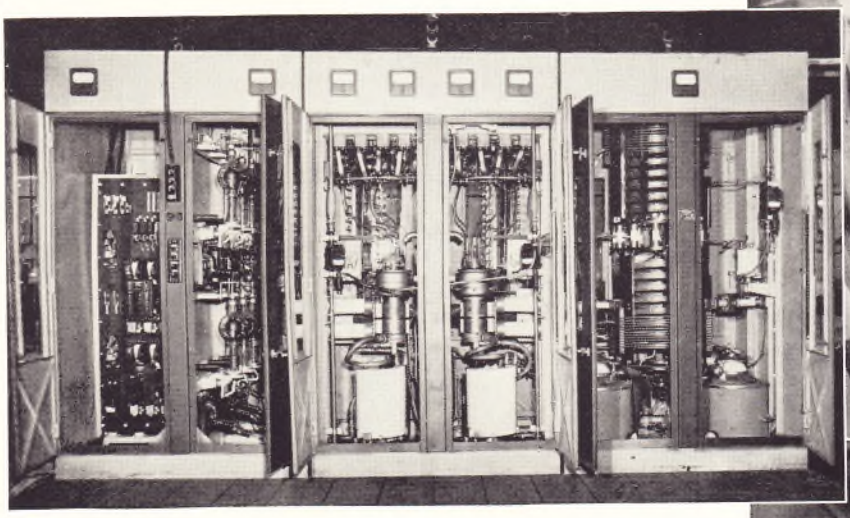
war's impetus, the creation of new high-speed motors for airplanes has been going forward at a rapid pace. Dynamometers suitable for testing motors and generators at speeds up to 20 000 rpm have not been available. Performance of ordinary high-speed motors has been reasonably well determined by extrapolation of curves based on data obtained at slower speeds and on one or two spot checks obtained by using the motors to drive high-speed fans of known characteristics. The performance of the new types of airplane motors, however, need to be determined with precision from actual test.

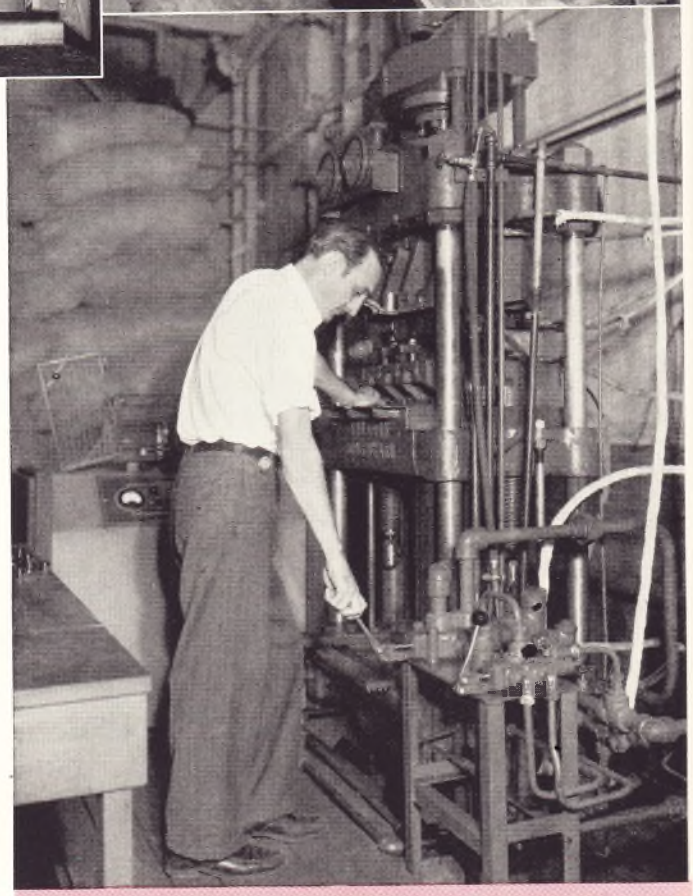
To help them analyze the performance of such machines, the small-motor designers have built their own test dynamometer. This dynamometer is capable of testing machines of 1/100 to 3/4 hp and is frequently operated at speeds of 25 000 rpm. It has been run as fast as 30 000 rpm. With the dynamometer needed so badly to test aircraft motors no attempt has been made to determine whether it can be safely run at higher speeds. The dynamometer is of the conventional cradle type, but uses special low-loss steel in the armature and embodies every known expedient to provide high bursting strength. The high-speed dynamometer is strictly a laboratory instrument; commercial models will not be available.

Railroad cars of tomorrow, complete with air conditioning, electric water coolers and air cleaners, and fluorescent lights, will need a 20-kw power plant. An axle-driven, high-speed 76-volt generator has been developed for this purpose with an a-c motor built into the frame to drive it when the train is stationary. Alternating current for the lights will come from a new lightweight 4-kw, 3600-rpm, a-c motor-generator set.

High-Frequency Generators, Off the Shelf

ASIDE from a continuation in great volume of experimental work on use of high frequencies for heating, an essential step has been taken in the development of induction and dielectric heating. The needs for generators of high-frequency power have crystalized to the point that engineers have created standard units. It is no longer necessary to have a generator designed to serve a given purpose. Most needs can be served well—and with all the advantages of standardized, stock units—by the range of powers and frequencies available in the accepted family of units. The smallest size unit has an output of but 1 kw, the largest 200 kw. Between them lie units of 2, 5, 10, 20, 50, and 100 kw. Each size is available for several frequencies over some portion of the 200 to 500 kilocycle, and 2 to 30 megacycle bands.





The acceptance of high-frequency oscillators by industrial engineers has undoubtedly been delayed by the maze of tubes, transformers, connections, and many mysterious appurtenances that seemed consonant with "radio" equipment. Designers have done much to dispel this psychological hurdle by providing generators that not only look simple, but are simple to operate. These stock units are completely self-contained. They require only electrical connection to a 60-cycle power source of 220 or 440 volts. Housed in a single cabinet, itself the handiwork of industrial artists, are the oscillator, power supply, blower, and switches. An automatic timing control permits load-cycle adjustment to a predetermined time, which can be automatically repeated. Terminals are provided for remote control. The larger size oscillators are benefiting from the unit construction idea. For example, the tank or output circuit can be removed and another one for a different frequency substituted.

The high-frequency laboratories have been going full tilt, exploring the possibilities of alternating-current heating of many products. Typical problems include the hardening of hack-saw teeth (without embrittlement of the supporting steel), the case hardening of wrist pins, the rapid curing of expensive woods, the heating of plastics, and a variety of food-processing operations.

While use of high frequencies does not provide the answer to every industrial heating problem, for many the advantages are striking. An excellent example is a two-kw oscillator in plastics manufacture. A great many common molded articles like electrical plugs, sockets, switch housings, mechanical parts, etc., are molded by the conventional method from a

This oscillator (upper left) provides 200 kw at high frequency for experimental use in the plant of the Federal Machine and Welder Co. (Top) On something like a mass-production basis 2-kw standard oscillators are being built for high-frequency heating. (Bottom) The oscillator cabinet to the left of the molding-press operator provides the high-frequency energy for preheating plastic preforms.

preform made of a wad of the plastic material which is placed in a hot mold, heated, and then subjected to high pressure and temperature for a curing period. The Bryant Electric Company, the Baldwin-Southwark Division of the Baldwin Locomotive Works, Monsanto Chemical Company, and Westinghouse have collaborated in an intensive study of the use of high frequencies for the preheating of plastic preforms.

These preheated preforms can be placed directly into the regular mold and because of their semi-plastic state resulting from the high-frequency heating, it is not necessary to use the high pressures now required in compression molding, which occasionally reach 5000 pounds per square inch. These lower pressures mean that smaller, less expensive presses can be used. Correspondingly, the initial cost of molds is less, their maintenance charges less, and they last one third longer.

The dielectric preheating also reduces the time normally taken to cure the material in the molds, which permits larger and quicker production from smaller capacity molds, thus effecting a saving in the original cost of the molding equipment. Tests have indicated that cure time is cut from minutes to seconds. The amount of "flash" (i.e., overflow) is much less. This means a saving of a few percent in amount of material used and a reduction in the time spent in finishing the product after it leaves the press.

Cleaned Air in Railroad Cars

In postwar railroad passenger cars, the air may be as clean as in a Maine woods. Cleaner perhaps. In cars equipped with electrostatic air cleaners, cinders, soot, and roadbed dust will be removed before the air goes through the air-conditioning system. Tobacco smoke no longer need annoy non-smokers. With Precipitrons every car can be a smoking car.

An experimental car of a progressive eastern railroad is being equipped with a specially built Precipitron. This unit borrows heavily from the experience gained with a unit installed before the war in a deluxe railroad car used in the west. The unit, however, is designed to go just under the roof at the end of the car instead of vertically in one section of a washroom. Also a simplified and more positive system of oil-washing the dirt from the plates at the end of the run has been devised.

With the car cleared continually of smoke and other dust the heating problem is simplified. It is not necessary to exhaust from the car such a large portion of the air. Because more of the air is recirculated, the amount of cold make-up air to be heated is greatly reduced.

Brazers That Go to the Work

Brazing is an old but still not too generally used method of joining members of copper, brass, bronze, or various alloys. One handicap has been the lack of brazing apparatus that can be readily taken to the job, as in shipyards, railroad shops. For the mass-production lines of factories, the well-developed brazing furnaces are in much demand, but there has been a need for portable units for joining wire cables, strap connectors, pipe, etc. This need is now met by a family of self-contained brazing sets that require only a connection to a 220-volt power source. These sets consist essentially of a transformer for providing high currents at low voltage, suitable voltage selectors, controls, and carbon-tipped tongs that can be clamped over the pieces to be joined. The high currents flowing through the carbons bring them to incandescence, quickly bringing the material to brazing temperatures, which are from 1200 to 1500 degrees F.

Three sizes, 5, 10, and 20 kva, comprise this group of mobile brazing elements. The 5- and the 10-kva units are air-cooled. The 20-kva unit is fan-cooled and has a self-contained water cooling and recirculating system used to cool the brazing cables and tongs. This cooling system permits the use of a small-size portable unit for medium brazing work. The smallest unit weighs but 30 pounds; the middle-size one, 100 pounds; and the 20 kva, 250 pounds. The corresponding secondary currents are 625, 833, and 1667 amperes.

More Welder, Less Weight

Out of a war necessity comes a new direct-current welder that will be of lasting value. On all types of fighting vessels, from landing craft to aircraft carriers and the largest battleships, welding sets are among the most vital of all repair tools. Considering the cramped spaces aboard these ships, small-size hatches, and need for portability, light weight is extremely important. In usual peacetime or industrial plant service use, light weight in welding sets has not been of prime importance. With the new need in mind, welder designers modified the previous satisfactory but rugged construction to pare down its weight. The results are astonishing. The new d-c to d-c 200-ampere welder weighs only 333 pounds. Compared to it the 150-ampere conventional welder weighed 500 pounds. In other words, a decrease of one third the weight is accompanied by a one third increase in current capacity. Furthermore the older machine was driven by an alternating-current motor which inherently weighs less than the d-c motor of the light-weight set.

This has been achieved without any change in basic form of construction, i.e., steel is still used for all structural parts. A large component of the weight reduction comes from a vastly improved ventilating system in which the underside of the core is, in particular, well ventilated. That no ruggedness has been sacrificed is indicated by its being able to meet the Navy's shock test.

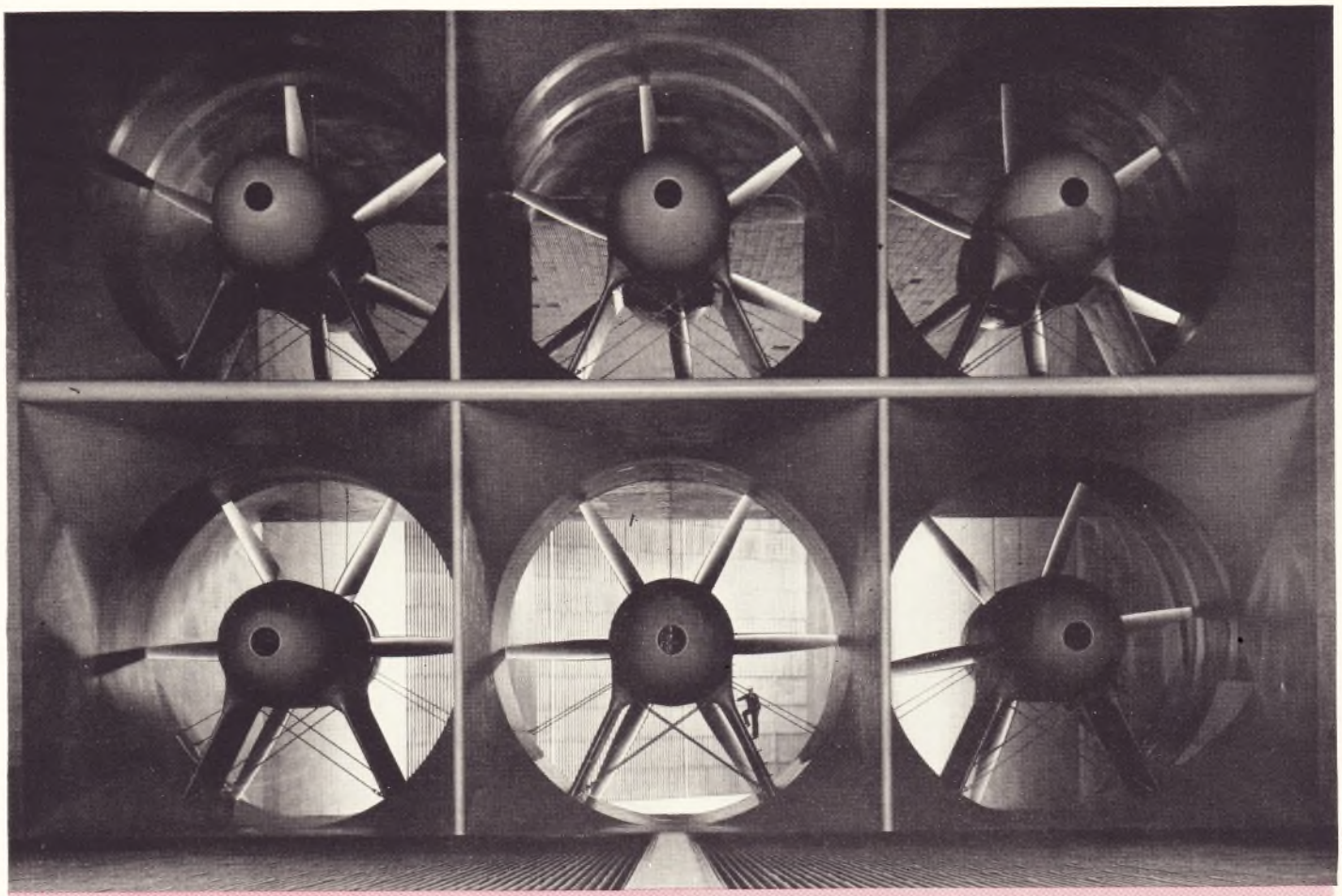
Because full-production capacity is being used to supply the Armed Services, these light-weight arc welders are not available for industrial use.

The pounds per ampere have reduced almost exactly half in this d-c welder. Originally designed for ship service, it should have many other uses when it can be made available for other than maritime emergencies.

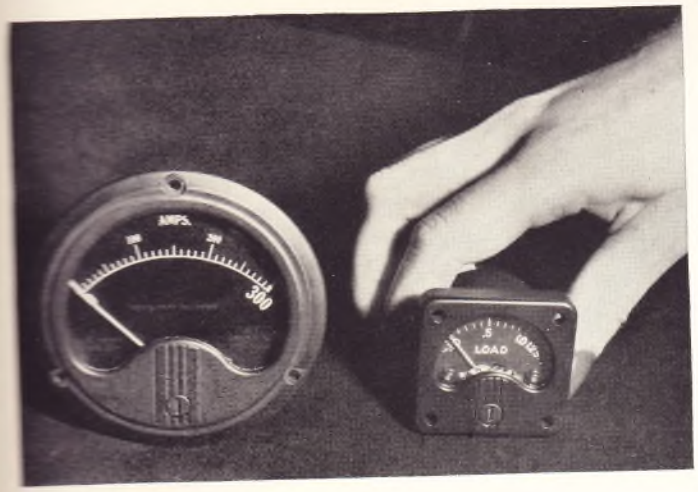
New Drives, New Controls for Wind Tunnels

WIND tunnels are becoming commonplace, but the engineering for them is not. Each of the numerous new tunnels recently installed or under construction entails new engineering features in the drives or control. Each tunnel is intended for a certain specialized class of aerodynamic research that makes it differ considerably from others and demands tailored engineering. Some tunnels are intended for testing full-scale models, others for observing behavior of models at high air velocities (even at supersonic air speeds, i.e., higher than 765 mph), for studies of the effects of icing, the fall of parachutes, models in spin and in free flight. In some the flow of air is studied over complete models, while in others the interest is in airplane components such as wing sections, cowling for engine cooling, control sections, fuselage, turrets, propeller and hub.

Most spectacular of the newer tunnels is the big one at Ames Laboratory, Moffett Field, California. The test section is 80 feet wide and 40 feet high, which is large enough to accommodate a full-size pursuit plane or some types of bombers. The test plane can actually be "flown" with the pilot at the controls and the engines running. To produce a wind of more than 200 miles per hour for so large a section requires six 6000-hp Westinghouse motors. These are arranged in two rows of three each, completely filling the tunnel section. The six wound-rotor induction motors must remain in synchronism at all speeds. To accomplish this all motor primaries are paralleled; likewise the secondaries are connected in parallel, something previously considered impossible with so many motors of such large size. This is achieved by special design of the motors and by use of the inherent dampening properties of propellers. The energy in the secondary circuit is salvaged by the modified Kramer type of drive used previously with conspicuous success, such as with the 40000-hp wind-tunnel motor at Wright Field, Ohio. An electronic regulator controls the field to the d-c machines of the secondary system to hold constant any desired air speed.



The cross-section of the Ames Laboratory wind tunnel at Moffett Field is huge as is indicated by the sailor. It is 172 feet wide by 132 feet high, big enough for a ten-story building. This is one reason six fans in parallel are used to provide the wind.



The new miniature ammeters are designed especially to save space on the crowded instrument panels of multi-engine bombing planes.

The wind tunnel at California Institute of Technology, built for cooperative research with several aircraft manufacturers, is of special interest because the fan is driven by an induction motor and a d-c motor in tandem. The 2000-hp d-c motor drives the fan for low-velocity winds. At higher speeds the 10 000-hp induction motor comes into play; the d-c motor takes load fluctuations to hold the speed constant. This type of drive is particularly meritorious when much testing is to be done at low air velocities because its power economy at low speeds is good. Also, the size of the equipment is approximately only one half that necessary with an a-c drive alone. In addition to variable speed, the California Tech tunnel employs a variable-pitch propeller. This tunnel is designed for variable-density air conditions over the range of one-quarter to four atmospheres.

Another interesting new type of drive is a variable-frequency system using a synchronous motor for the propeller drive. Power is supplied by an m-g set.

The motors for several new wind tunnels are being equipped with Rototrol regulators for accurate speed control. This is a special rotary amplifier with characteristics that enable it to control the speed of the main fan motor so accurately that variations from any desired speed do not exceed one quarter of one percent.

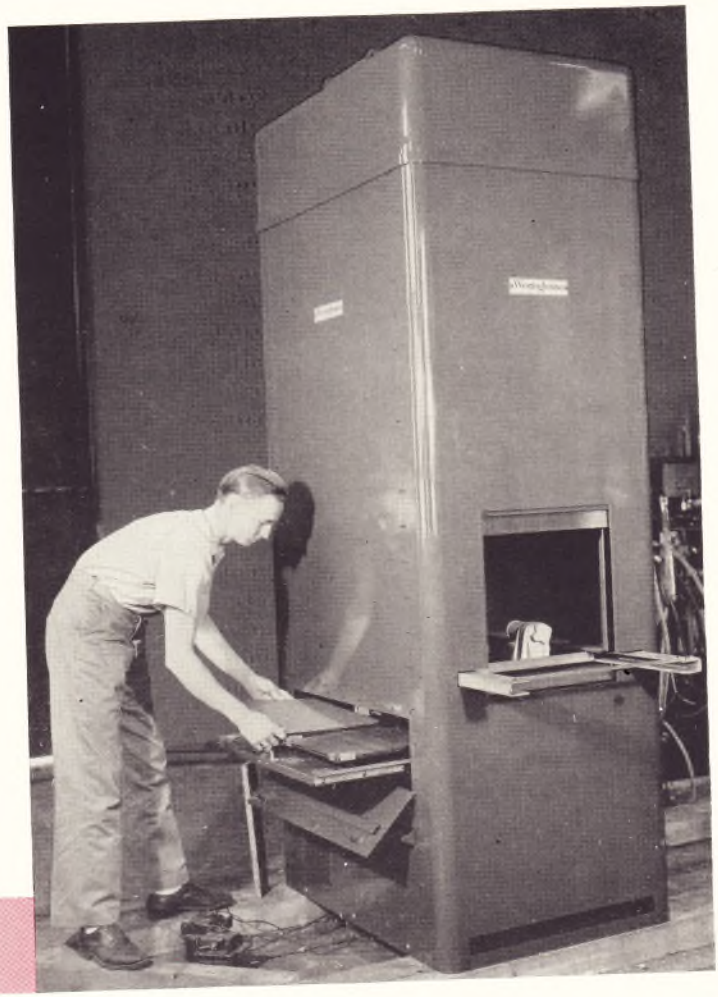
X-rays Serve the Production Line

THE x-ray is successful as a manufacturing inspection unit because it is adaptable to the production program and does not impede the smooth flow of products. X-ray equipment has been removed from remote, large, lead-lined rooms to a position astride the production line. An example of that flexibility occurred last year in a plant making light-metal parts for aircraft. Some parts are small and thin, others are thick and of considerable size. Obviously, a single x-ray exposure is inadequate. The problem was solved by providing two x-ray machines, astride the conveyor line and spaced with respect to the trays loaded with parts to be inspected. One machine makes an exposure for the heavy-density parts as the other machine makes a simultaneous exposure for the thinner areas. Furthermore, the operation of both machines can be automatic, with the heavy lead walls of the units closing about the part when the exposure is made. If production should be shifted so that only heavy parts are placed in one tray and light ones in the next, the x-ray machines can be easily reset to meet this situation because lead-lined rooms are no longer needed for personnel protection.

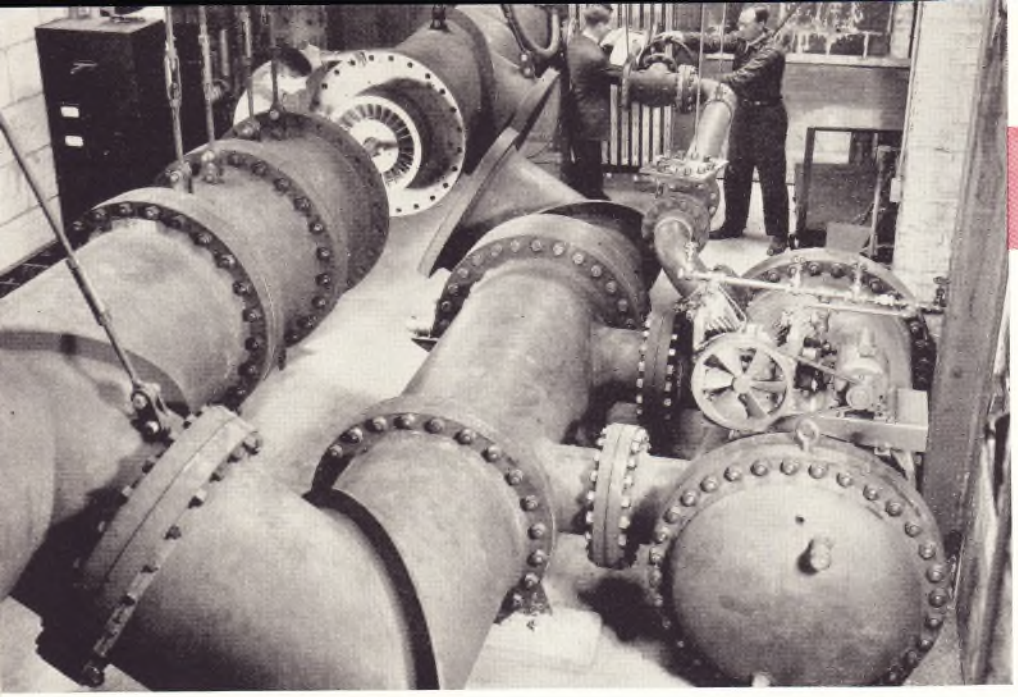
Smaller Instruments for Bigger Airplanes

THE Superfortress (B-29) has six main and one ground-service generating plants. This means that at any one time several d-c generators should be sharing load. Seven standard aircraft ammeters simply occupy more panel space than can be spared for them. The obvious alternative of using but a single instrument and switching it from generator to generator is not feasible because six readings are too many to remember, and making written records adds too much to the operator's duties.

A way out of this difficulty has been provided by the creation of a miniature instrument. This compact ammeter does, with almost no sacrifice in performance, in 1¾-inch square panel space, what previous instruments have done with 2½- and 3½-inch squares. This means the seven ammeters occupy less than 22 square inches of panel space instead of the 74 required by the 3¼-inch variety. Each instrument weighs but four ounces, a saving of 79 percent. The smaller instrument uses many of the same parts as the larger ones; in fact, the moving element is identical. The miniature sacrifices less in scale readability than would be expected; the new dial is 1.2 inches long instead of 1.8 inches for the 2½-inch instrument.



X-ray units like this are made so they will fit into production-line set-ups, the conveyor line passing through the cabinet.



Preliminary testing of proposed new turbine blades can be conducted in short order with this new wind tunnel. Models are of wood.

New Wind Tunnel for Turbine Blades

THE AERODYNAMICS of new, experimental steam-turbine blades can be measured far more quickly than heretofore. The wind tunnel used before provides information on the aerodynamics of blades in high-velocity gases, and gives the exact, accurate answers needed for final designs. However, because the blade models are subjected to high velocity they must be carefully fashioned of steel; the wind tunnel itself is massive, and requires a great deal of power to drive it. As a result, seldom can a half dozen tests be made in a year. The new tunnel, on the other hand, drives the blades at low speed but in a medium of high pressure (220 pounds instead of atmospheric). Under these conditions the models can be fashioned of wood. Variations in model shape and position can be tried in a few hours instead of weeks.

This type of testing is possible because the air-flow data is acceptably accurate if the pressure is increased as the air speed is decreased, in such a ratio that the factor known as the Reynolds number is unchanged. For velocities well below that of sound (i.e., where compressibility of the air is not a large factor) the results obtained with the high-pressure tunnel are reasonably accurate, certainly within limits required in the preliminary stages of a blade or nozzle study. This allows a great many variations to be tried quickly, greatly expediting the final designs, which can be given rigorous tests by the slower, but more precise method.

Instruments Remagnetized Electronically

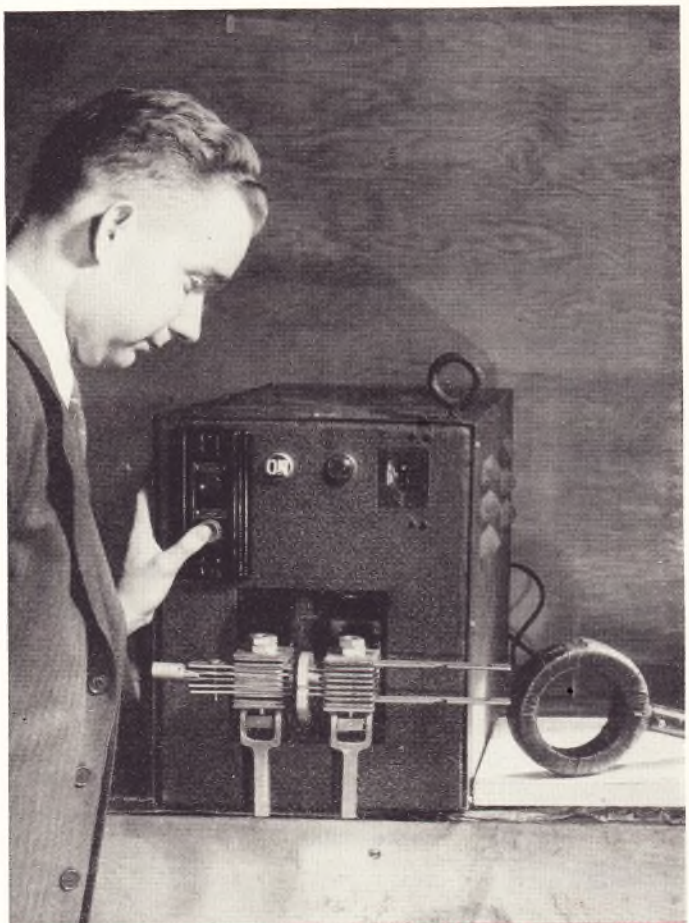
MANY a flak-riddled plane has staggered home, crash landed, and yet lived to fly again through prodigies of repair performed in the field. Not only the plane, but also its instruments need maintenance and repair, not by being returned—perhaps thousands of miles—to the factory, but in the fields, and fast. An electronic instrument magnetizer, which operates from any 110-volt, 60-cycle, single-phase line, aids in the complete overhaul and calibration of essential instruments by remagnetizing magnets, quickly and accurately.

Essentially, the magnetizer consists of a single-phase, full-wave, electronic-tube rectifier that charges a bank of capacitors. When fully charged, the capacitors are discharged by means of a thyratron tube through a magnetizing transformer. The magnet to be remagnetized is placed within the secondary loop of the transformer and acted upon by the unidirectional currents of high magnitude.

The momentary load on the supply line imposed by the controlled half-cycle magnetizer, a similar instrument, ranges from 50 to 100 kva. The power requirements of the new meter magnetizer, when the capacitors are being charged (reflecting the worst possible conditions) will not exceed two kva. This demand drops rapidly in a few cycles.

An adjustable output for the magnetizer accommodates the requirements of various types and sizes of instrument magnets. The magnet is suspended in the secondary loop about a connecting link made of copper leaves. When full magnetizing current (50 000 amperes) is desired, all the leaves are used. Decreasing the number of leaves limits the current to any desired figure. In ordinary practice, the instrument magnet is fully magnetized. Its strength is reduced to the proper number of gausses by means of an a-c coil.

The instrument magnetizer is of value not only for field emergency instrument repair work but also will fill a definite need for such a device in repair shops.



Instrument magnets are overmagnetized with this apparatus and demagnetized to a specified strength for calibration purposes by the doughnut-shaped coil to the right.

Portable Instruments Have Many War Jobs

EVERY booby trap, every land mine that goes off to do its deadly work must first be planted. When a land mine is planted it must be checked to insure that it will explode. This is done by passing through the electrical circuit of the mine a tiny current—not enough to set it off, but enough to prove the circuit continuity.

For this checking of mines the Army needed thousands of small, portable ohmmeters. A new type of portable instrument almost ready for peaceful pursuits at the time of the Pearl Harbor attack, but shelved for patriotic and materials reasons, was dusted off and found to be just the ticket. This tiny instrument is about the size of a cake of laundry soap, the overall dimensions being only three by four by one and one half inches. Although the molded case must also contain the dry cell, the instrument is small enough to slip into a coat pocket. For all its small size it has excellent accuracy, two percent, which is more than is needed for the mine-checking chore. Accuracy can be doubled for work that demands it by the addition of internal shielding, for which provision is made.

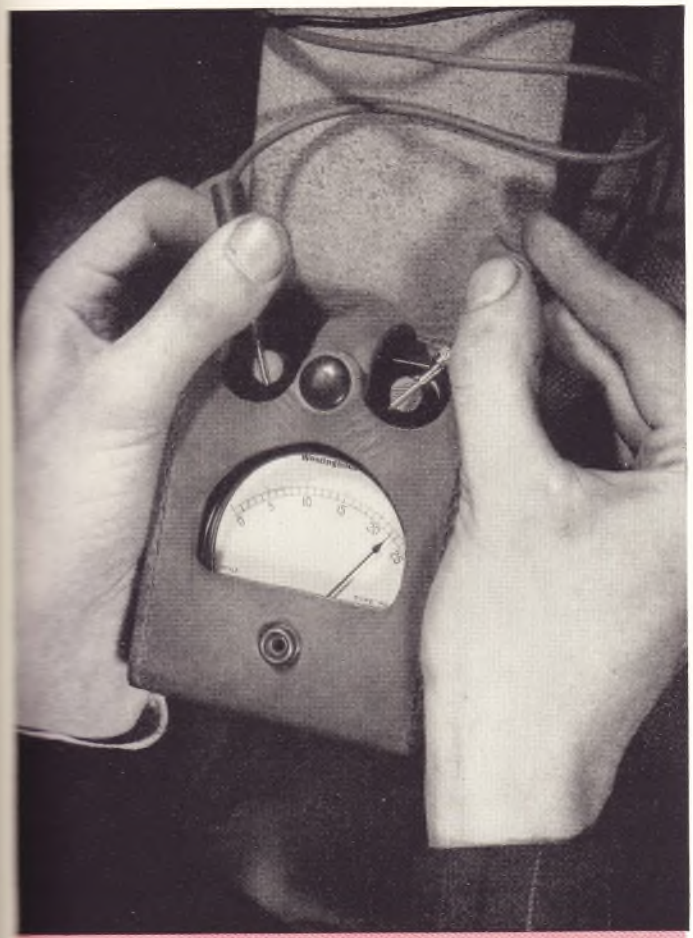
This remarkably compact instrument will have many peacetime applications. Indeed, that was its original purpose. It has simply taken time out to help win the war.

The bigger brother of the mine-checking portable instrument, also about ready for peacetime jobs when the war came, has likewise had an interesting war-service record. It joined the Air Forces, so to speak. Fighting planes, particularly bombers, are now so dependent upon their elaborate electrical systems that a multi-purpose portable electrical instrument is as essential in the plane's tool kit as pliers and screw driver. One of these medium-size portable instruments is in the maintenance kit of every airplane of certain types. Its overall dimensions are but four by five by two inches. Being larger than the one used for checking mines, its accuracy is better (one half percent at airplane-battery voltage). As built for aircraft service, the instrument has three scales and can indicate either currents or voltages.

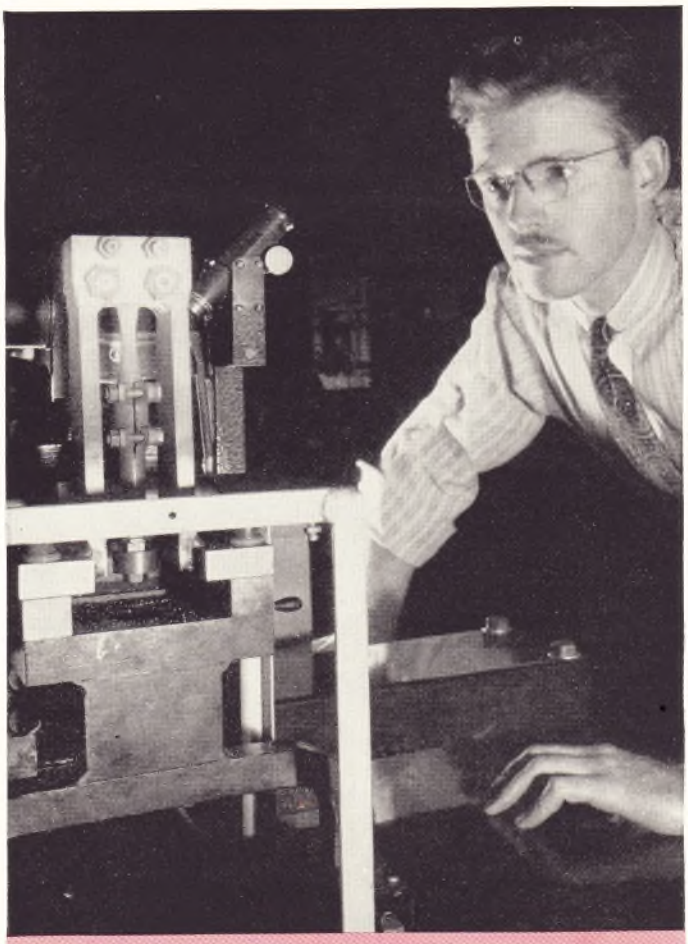
This instrument's war uniform is a leather case. However, as it was originally intended for peacetime use, it was designed on the Westinghouse standardized chassis basis. In less time than it takes to tell about it, the instrument can be provided with a molded, hinged cover, left as an open-face bench-type model, or equipped for carrying.

A Billion Stresses in a Hurry

WITH STEAM and gas turbines, superchargers and other high-temperature machines resting squarely on the development of high-temperature alloys, the impatience of engineers with endurance test methods that require five or six years is understandable. At room temperature, the limit of endurance of a metal is usually reached in ten million cycles of stress. But, at elevated temperatures, the strength initially is lower but declines more slowly and the sample may survive several hundred million cycles before it breaks. To stress an



Midget-size portable instruments like this have a multiplicity of war jobs, such as checking circuit continuity of land mines, and maintenance of battle-worn equipment.



In machines like this alloys for high temperatures are born. The test piece, glowing red with heat, is in the upper yoke of the machine that applies 120 stresses per second.

alloy sample a quarter of a billion times by ordinary means consumes years.

Several test machines have been made that do this testing job in a month. The test piece is clamped in a furnace that maintains the desired temperature. Through the clamping structure is applied a stress 120 times per second by two stator coils connected to a two-phase, 60-cycle supply line. The entire system is mechanically tuned to resonance at this frequency to minimize the driving force necessary.

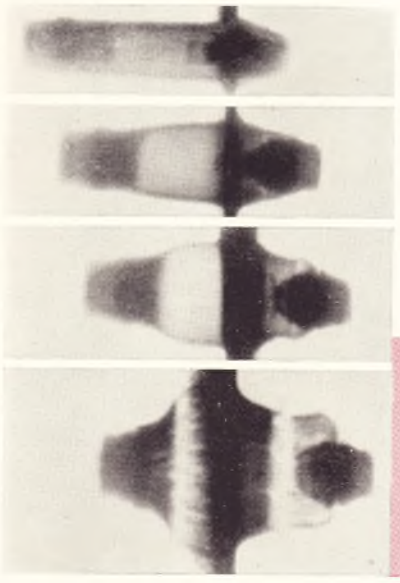
This tuning serves a second highly desirable purpose. Research engineers want to see the specimen after the first tiny crack occurs, not after the complete failure of the sample. With this device, the first crack in the sample reduces the stiffness of the system, which detunes the mechanism to such an extent that the machine automatically stops. The test can be allowed to run day and night without attention for weeks or months until the inception of failure. The machine then quickly stops itself so that important evidence of the mechanism of failure is not destroyed. Specimens of high-temperature alloys have been stressed a billion times in 100 days, a saving of many months.

X-ray Pictures in a Millionth of a Second

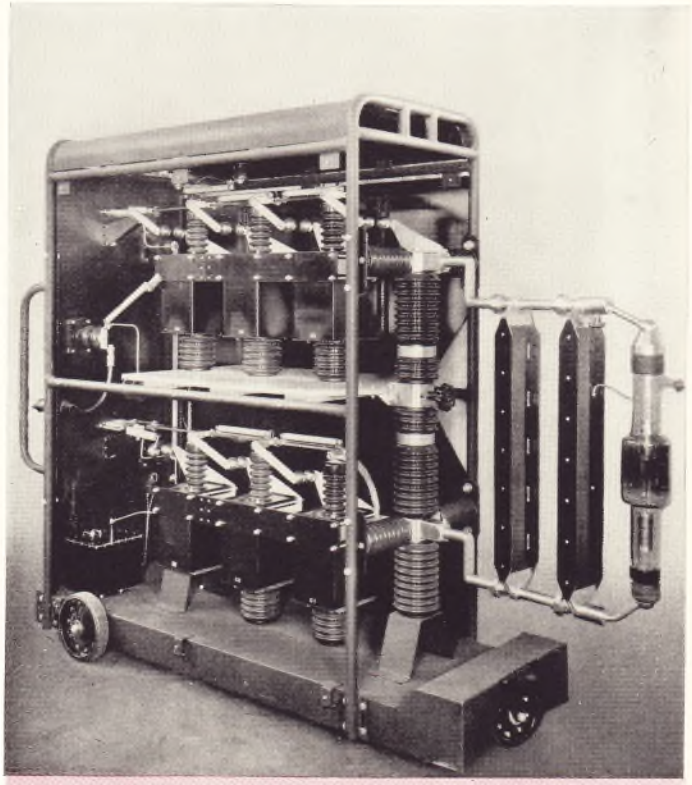
ONE TOOL important in this war uses more power than the city of St. Louis, costs more to run than the war itself, and has a total life of one thousandth of a second. It is a high-speed x-ray unit, capable of making pictures in a time as short as one millionth of a second. For such a picture an enormous burst of power is released through the tube, about 2000 amperes at 300 kv, which is 600 000 kw for a microsecond. Although a single picture costs only a dollar, that sum is spent at the rate of 3.6 billion dollars per hour. The tube can be used a thousand times; but, because each exposure lasts only a millionth of a second, the total service life of the tube is only a small part of a second.

Most obvious use of such high-speed x-raying is in ballistic studies. A great deal of pioneer work in this field has been done at Frankford Arsenal. It has been used there to determine the location of a projectile in a gun barrel with respect to the curve of gas pressure versus time. The effects of the rapid acceleration on the component parts of composite projectiles such as explosive bullets, and the manner of progression of a projectile through armor can be similarly recorded. Pictures of actual penetration taken by ordinary high-speed photographic means are obscured by luminous fragments created by projectile impact.

Such high-speed x-ray pictures are expected to have many non-military uses such as studies of rapid chemical reactions, the movements of valves, springs, and cams of engines.



A series of x-rays of a shell piercing armor plate, each taken in about a millionth of a second. It discloses that the shell swells to nearly twice size before bursting.



The high-speed x-ray machine consists of a bank of capacitors that discharge through a special tube, at the extreme right.

The high-speed x-ray machine, surprisingly enough, is extremely simple—in many ways simpler than the ordinary type. A surge generator is charged slowly and then suddenly discharged through a high-vacuum tube. The tube is of special design to utilize the short pulse of a large amount of energy to produce x-radiation of abnormally high intensity.

The fact that the power is stored in capacitors suggests another use for the apparatus. The energy, if discharged as an arc in air instead of through the tube, provides the excellent short-lived but intense illumination required for ordinary high-speed spark photographic work, thereby eliminating the need for a high-speed shutter. Thus the device can be used either for taking high-speed x-ray pictures or as a light source for ordinary high-speed pictures.

Recording Vibration on Location

DEVICES for resolving vibration into its component frequencies and amplitudes with great precision have long been available. But, mostly they are for use in the laboratory or factory. The need is for some quick, simple means of recording the vibration where it occurs, which may be some remote corner of a plant far removed from laboratory facilities.

Aimed squarely at this requirement is a "little black box" called the Vibrograph. It is about the size of an ordinary box camera, weighs less than nine pounds, and requires no power connection. It writes a permanent record of vibrations whose frequencies are within the range of 600 to 15 000 cycles per minute and with amplitudes as low as one ten thousandth of an inch or as great as one sixteenth of an inch. The vibration record and a timing wave are drawn by a stylus on a transparent plastic tape one inch wide.

The portable vibration recorder mechanically amplifies the vibration and traces it with a record of time on a ribbon.

Phototube, Newest X-ray Assistant

A NEW KIND of timer does for the x-ray technician what the exposure meter does for the amateur photographer. Consider the variables confronting the operator about to x-ray a human chest. In order to produce an exposure of the proper density on the film he must weigh several factors: thickness and structure of the chest, whether the patient is male or female, the voltage to apply to the x-ray tube, the proper current to discharge through the tube and for how long. Judgment of so many variables not only is subject to error, but also takes time. With the present trend toward x-ray examination of masses of people—perhaps as many as 1000 per day at a single location—this time factor is important.

Exposures are now timed automatically by a mechanism conceived by Dr. Russell Morgan. It weighs all factors and produces negatives of constant density regardless of differences in patients. Furthermore, it makes its computation during the exposure, and if, for any reason, the correct exposure is not made, it sounds a warning bell so an x-ray can be retaken before the patient leaves.

The technician simply makes an approximate voltage setting—high, medium, or low—and starts the exposure. Some of the x-radiation passing through the patient's body falls on a fluorescent screen producing visible light that is viewed by a phototube. The tube integrates the amount of light coming from the fluorescent screen and stops the exposure at the right time. The timer also allows for the time that will be required for the relays to open. This computation of x-ray exposure by the phototube and the operation of the circuit is fast.

Times of x-ray exposures are as little as 1/30 of a second. But for electronic devices this is a long time.

X-rays Aid Rockets

IN BALTIMORE, one day last summer, a loaded freight car was switched to the rear end of one of the famous passenger trains for Chicago. There it was quickly connected to one of the big-name trains that shuttle between Chicago and the Pacific Coast. At a small town in the Middle West this fast passenger train stopped to switch its high-priority freight car directly to a plant of the Hercules Powder Company.

The freight that merited this unprecedented attention was an x-ray machine. Awaiting it was a rocket fuel for a new type of shell, which has since played a spectacular part in the rout of the Germans from France.

The rocket fuel is extruded in solid form. Any voids—even small ones—in it mean loss of range, uneven propulsion of the shell. The purpose of x-raying is to detect these voids.

The x-ray set is not unusual, being virtually the standard 220-kv, factory-inspection-type equipment. The hazardous nature of the product, however, required an unusual enclosure for it. This is a lead-lined chamber equipped with a sensitive temperature indicator and photoelectric tube that turns on torrents of water from several nozzles should a stick of the jet fuel start to burn.

The x-ray inspection of the rocket fuel is essentially automatic. Small carriages with the sticks lying directly on x-ray plates are passed into the chamber through a door on one side. The lead-lined doors close automatically, exposures are made, and the door on the opposite side opens automatically for the removal of the carriage.

In the new electronic oscillograph the electron beam traveling at times 600 miles a second writes on photographic film sharp, detailed records of electrical phenomena lasting for as little as a tenth of a millionth of a second. In modern guise the cathode-ray oscillograph serves an expanding group of industries such as public utilities, manufacturers, and aircraft-engine ignition makers.

A New Superior High-Frequency Insulation

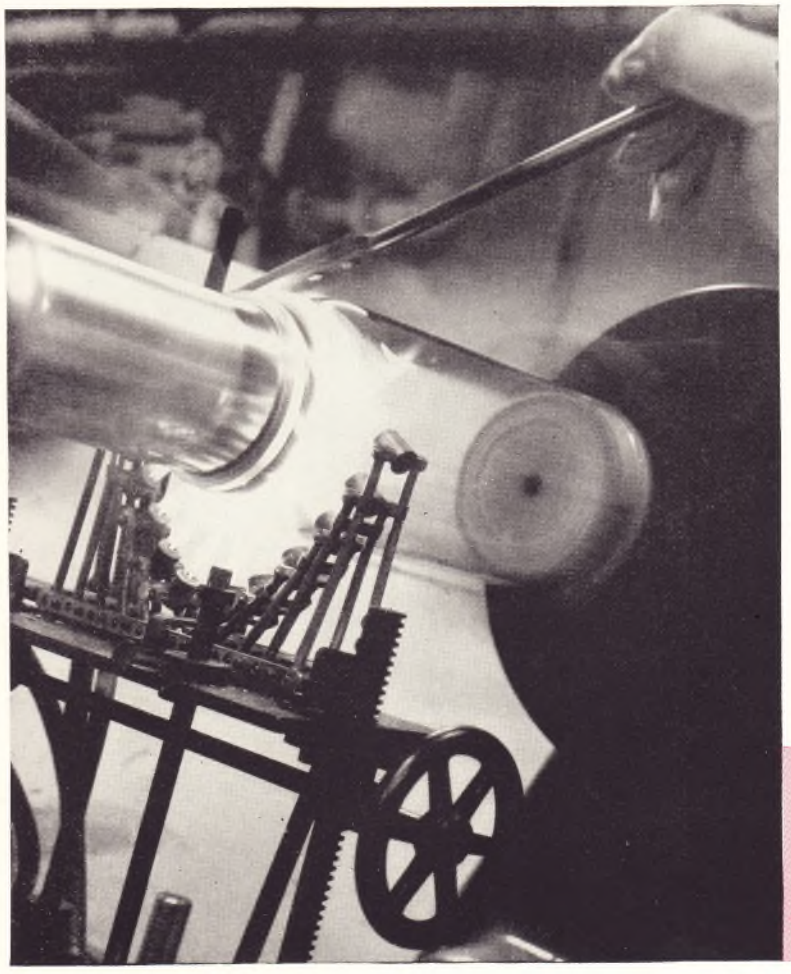
RANKING near the top of the list of materials critically short in the war-production program have been electrical insulators for ultra-high frequency signaling equipment. High-voltage porcelains and similar solid insulations, while adequate mechanically and electrically for low-frequency duty, have excessive energy losses when subjected to voltages in megacycle bands. These large dielectric losses at high frequencies are serious. Not only do they handicap the design and performance of such radio equipment, but also the power loss itself is of concern because the power involved at these super-frequencies is small to begin with. About the only acceptable ceramic material available in commercial quantity has been Steatite porcelain, a ceramic produced by several manufacturers from mineral talc, clay, and flux. The production of Steatite porcelain has been limited by the sources of usable talc and by the stringent conditions imposed on its processing to such an extent that the production of desperately needed high-frequency signaling equipment has depended at times on the Steatite porcelain available.

Now an entirely different type of electrical insulating material has been developed. Furthermore, it is superior to Steatite in several ways and inferior in but only two minor ones. This new ceramic insulation is Zircon porcelain.

A type of Zircon porcelain has long been known to be an excellent ceramic material for spark-plug insulation because of its resistance to heat shock and to current leakage when hot. However, Zircon porcelain received little consideration for high-frequency use until 1942 when a different type of Zircon porcelain was developed. Tests show this porcelain, consisting mostly of the mineral Zircon (which is a double oxide of zirconium and silicon) plus some clay and flux, to have superb electrical and physical qualities.

Mineral Zircon is found in the sands of beaches in many parts of the world including Florida, India, Brazil, and Australia, and the material is replenished by the sea. It is also a common constituent of many igneous rocks. It is uniform in constituency and poses no unusual raw-material processing difficulties. Uniform Zircon ceramics are thus produced from abundant raw materials.

Its loss factor at high frequency is superior to all Steatite except those grades known as ultra-Steatite. Aside from the much better electrical characteristics, Zircon porcelain is characterized by improved mechanical properties. For example, the tensile strength of Zircon is some 37 percent greater than that of standard commercial high-frequency porcelain insulation; the compressive strength is approximately 15 percent greater and the resistance to transverse blows is approximately 30 percent greater. Because of the greater inherent density, Zircon is even more impervious to moisture than is Steatite, which has good moisture resistance. Its ability to withstand heat shock, i.e., sudden large changes in temperature is excellent, as indicated by its use as spark-plug material. Steatite porcelain is decidedly inferior in this respect.

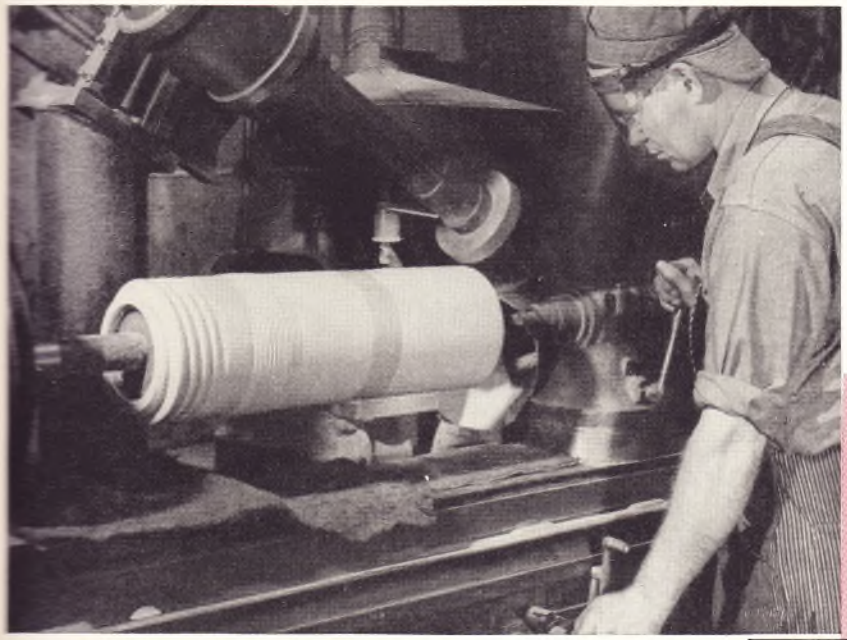


With the war dependent on electron tubes, one unalterable fact of nature, the difference in expansion of metal and glass, could have become a serious obstacle. Kovar saved the day. Born of Westinghouse research, it is an alloy of iron, nickel, and cobalt with rate of expansion closely paralleling that of hard glass. As is being done here, making a Kovar-to-glass seal is a simple matter.

Zircon porcelain is about one third heavier than Steatite, although this can be offset in most designs by its greater strength. The specific inductive capacity is somewhat higher than that of Steatite.

Zircon porcelain can be readily processed with standard equipment by any of the methods used for forming high-tension electrical porcelain, such as pressure forming in steel dies (dry or wet process) and plastic forming. Signal success has been achieved with the "Prestite" method, a semi-wet pressing process by which a uniform density is developed.

To our list of war-born materials of great permanent value must be placed the new high-frequency electrical insulation known as Zircon porcelain.



Thinner Hipersil for Higher Frequencies

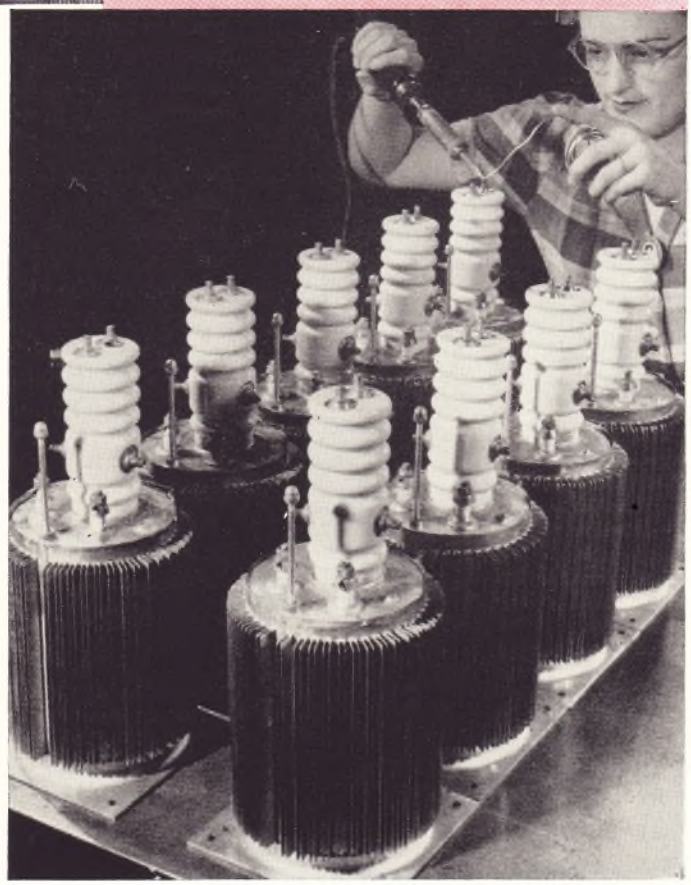
THE CREATION, under tremendous pressure of war needs, of radio signaling systems and other radio-type equipments at extremely high frequencies far beyond any prewar concept has brought with it "must" demands for scores of types of special transformers that never before existed. Transformer engineers have replied with units that, viewed by ordinary standards, are freaks of the first order. For example, consider a transformer no bigger than your fist yet able to deliver 100 kw (for extremely brief intervals, of course). Another complete transformer weighs but one-half ounce and uses a metal radio-tube case as an enclosure.

The pressure on transformer designers for small size, light weight, and high capacity in these midget transformers comes from two directions. Much of this equipment is air-borne where the need for weight and space saving is obvious. The other is that as the frequency increases the thickness of the core laminations should decrease. At frequencies of several thousand kilocycles the flux changes so rapidly it is not able to penetrate fully the magnetic material. A sort of magnetic skin effect comes into play. At these frequencies the flux does not penetrate more than five or ten percent of the standard lamination. Thus to keep down eddy-current loss, which at these frequencies tends to eat up appreciable proportions of the meager power available, the laminations should be thin, very thin—i.e., have as much surface as possible. The production of the ultra-thin thicknesses of grain-oriented Hipersil by the engineers of the American Rolling Mill and Westinghouse is a major accomplishment.

Prewar standard Hipersil laminations were 29 gauge, or about 14 mils thick. Then came 7-mil Hipersil, used extensively for 400-cycle aircraft transforming equipment, with an attendant saving of about 30 percent in total weight. As rolling-mill techniques improved, the 7-mil strip was outmoded by one 5 mils thick. But, for transformers in the high-frequency band and those that deliver power for but a tiny fraction of a second, 5-mil steel is much too thick. A new type of rolling mill was built which can produce grain-oriented steel, consistent in quality and only two mils thick. It makes possible transformers in which iron cores have not previously been possible because of the intolerably high core losses. Such transformers will, for example, be a great boon in television, which requires high peaks of power in pulses lasting but a fraction of a millionth of a second.

Now engineers have produced on an experimental basis a Hipersil steel only half as thick as the two-mil steel. Four layers of this one-mil Hipersil would be required to equal the thickness of this paper. Such steel when it can be produced on a commercial basis will mean a 20 to 50 percent further saving in weight, or, more important still, greater power available.

Although Zircon, the new porcelain with very low loss at ultra-high frequencies, is usually made into small parts such as insulators for radio equipment, sizable pieces can also be made from it, as at the left, where the application justifies the higher cost. Below are transformers, having striking resemblance to power transformers, with thin-gauge Hipersil cores for ultra-high frequency apparatus. They are oil filled, hermetically sealed.



Insulation Emancipation

BASIC improvements in electrical apparatus occur but rarely. New silicone insulating resins, however, rightfully deserve to be included as such. Certainly this distinction belongs to any development by which the output of a given size machine already well developed is increased a fourth, or the size and bulk reduced by a fifth. Silicone resins do this.

Ever since someone many years ago wound a coil with taped wire and painted it with varnish, electrical machines have depended to some degree on organic materials. These materials set the upper limit of temperature that electrical apparatus can endure. These organic insulations have been gradually improved over the years, but they are still organic in nature and possess the temperature limits of such. The development and improvement of inorganic solid insulations such as glass tape have been important, but fullest use of their high-temperature qualities cannot be utilized as long as they must be bonded with organic varnishes.

The new silicones now eliminate the weak link in the chain of high-temperature insulations. Silicones are synthetic products having physical properties comparable to conventional organic materials but are characterized by a chemical structure in which silicone takes the place of carbon in certain portions of the molecule. They can be applied to wound apparatus in the same manner as ordinary varnishes but must be baked at higher temperatures than conventional varnishes. The baked silicone films are unusually water and temperature resistant. Whereas, on a comparative basis, the maximum allowable temperature for organic insulations (class A) is 105 degrees C, and for inorganic materials such as glass, mica, and asbestos with organic binder (class B) is 130 degrees, silicone resins are good for 175 degrees. Thus, the new insulations are superior to class-B materials.

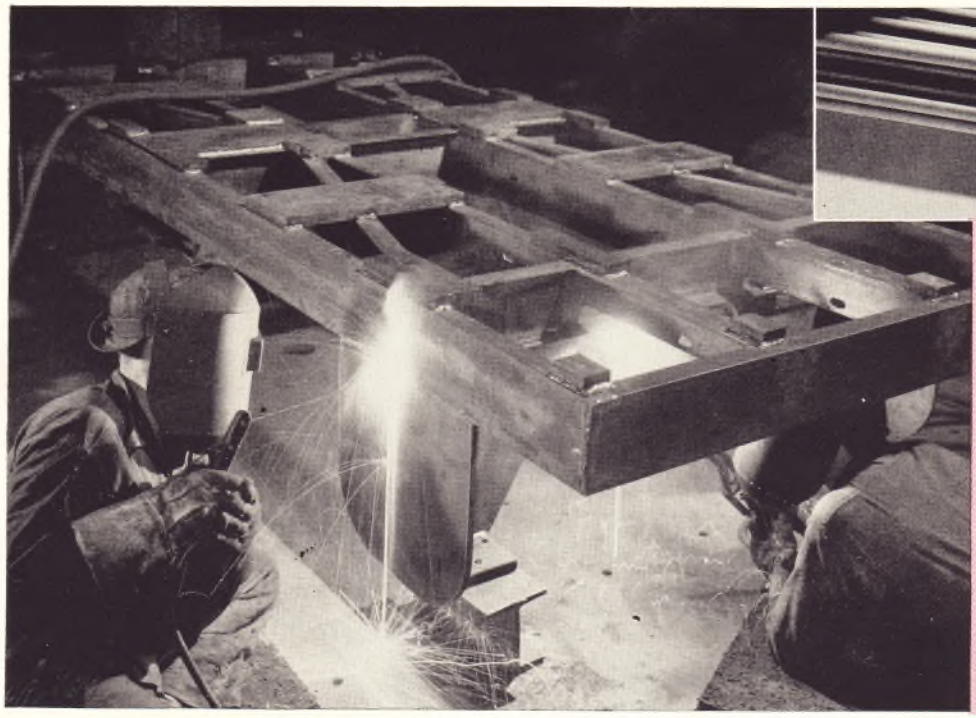
The silicone resins have been used in an experimental way on a wide variety of electrical apparatus. Representative design data indicate that a 2200-hp, low-speed d-c motor with silicone insulation will weigh 20 percent less than a similar machine with standard class-B insulation. An experimental fan-cooled induction motor was operated for 3200 hours at 250 degrees C total hot-spot temperature with an output of 25 hp (with class-B insulation this machine was rated at 15 hp). Generators, large a-c motors, magnet coils, transformers of various types have been built with the new synthetic resins with comparable gains in rating or reduction in size. Tests over long periods give assurance that these gains are real.

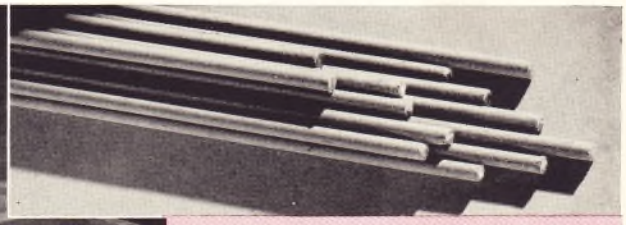
It is unlikely that silicone resins will replace, for some time at least, conventional varnishes. The high baking temperatures and the cost of the material, which is at present several times more than regular varnishes, make universal use impractical. Also, in many cases other things than temperature, such as bearings, torques, etc., limit the rating or size. Silicone resins are of greatest value for those machines in which temperature sets the limit, where ambient temperatures are high, where space is limited, or more rating is required in a given space.

A New Hot-Formed Molded Laminate

Combining the desirable molding properties of thermoplastic materials and the good physical characteristics of thermosetting materials, a new plastic has been developed by modifying the resin in standard Micarta. This causes the substance to soften when hot, as do thermoplastic materials, but at a much higher temperature, about 300 degrees F, which is far above the service range. The new Micarta can be heated and pressed into deep-drawn and complicated shapes at lower pressures—about 50 to 100 pounds—and requires much less time for curing than do thermosetting resins. Since dies can be made of hard wood or thermosetting laminates, small numbers of parts can be made economically.

When cool the product has the good strength and freedom from embrittlement characteristic of many thermosetting materials. Its use for nonstructural and semistructural aircraft parts makes possible a reduction in weight of more than fifty percent. In one particular operation, a single sheet of formed Micarta replaced an airplane part made of four separate pieces of aluminum joined with forty inches of weld. The Micarta part weighed half as much, required 19 minutes to produce compared to 75 minutes for the metal part.





The use of a-c welding, particularly for vertical and over-head work, has been hampered by the lack of an all-position a-c electrode capable of producing highest quality weld metal. Long a research project, an a-c electrode, known as the ACP, has emerged that meets the requirements of the U. S. Navy Department Bureau of Ships and the standards for welding set by various associations. The new electrode includes an arc pacifier that prevents excessive spatter loss during the negative half cycles and an arc stabilizer to aid in reestablishing the arc after each current zero.

ENGINEERING PROFILES

The firefly has long been held up as a model to the lamp engineer, because of the erroneous belief that its light is produced with almost no energy consumption. The lamp engineer has done much better. A new type of glow lamp, the size of an average marble, emits continuously more light than hundreds of fireflies with an energy input that in a year's continuous burning does not add up to one kilowatthour. In a year, at average domestic power rates, it consumes less than three cents' worth of electrical energy.

The glow lamp actually is a miniature fluorescent lamp. A discharge takes place in a rare gas and the resulting radiation (invisible) is converted by

phosphors on the inner walls of the bulb into a soft green glow. A tiny resistance in the miniature screw base serves as ballast.

The green light from this lamp fortunately falls in the region of maximum night sensitivity of the eye. Held beside a neon glow lamp of the same wattage in the daytime, the two lamps would be judged of equal brightness. However, to dark-accustomed eyes the green glow lamp appears four times brighter. Thus, the green glow lamp is ideally suited as a night light in bathrooms, stairways, and halls.

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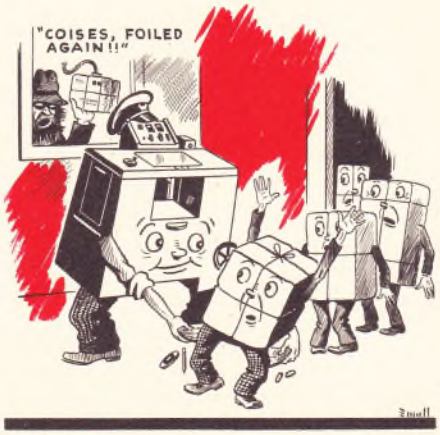
The pathetically amusing fanatic who tries to dispose of some fancied enemy by mailing him a bomb has long lived in story and cartoon. Fortunately, he rarely exists in reality. But not rarely enough. Those who serve conspicuous personages, such as high government officials, editors of crusading newspapers, district attorneys, etc., need protection from such lunacy. Likewise customs inspectors and police departments have need for looking inside packages—without opening them—ranging in size from that of a fountain pen to an orange crate.

X-ray sets have been adapted to this



purpose. A unit is about the size of a kitchen range, and embodies a substantially standard 140-kv x-ray machine arranged both for taking pictures on standard 14-by-17 inch film and for fluoroscopic viewing of the package innards. Packages in sizes up to a foot square and three feet long can be placed inside on a platform on which the film rests. The platform can be raised or lowered to accommodate different size packages.

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Engineers have done little about the middle component in the three-step laundry problem—washing, drying, ironing. That neglect is being remedied with dispatch. An electric dryer becomes the companion unit to the Laundramat. The dryer, externally similar to the Laundramat, contains a large metal tub in which the damp clothes are placed. The tub is rotated at slow speed while a fan circulates a current of air, warmed by electric heaters, that carries away the moisture.

The whole operation is automatic. The dryer even knows when the clothes are dry and turns off the heaters. When the moisture has been evaporated from the clothes, the air temperature abruptly rises. A temperature detector senses this and opens the heater circuit.

At the discretion of the operator, the tub can be stopped automatically when the clothes are dry or can be left turning until the operator is ready to remove them. The latter method is recommended for flat work where a soft finish is required. This tumbling or fluffing process offers an improvement on clothesline drying in that many pieces so treated need no ironing. Clothes hung on a line or rack dry with the wrinkles in them, whereas clothes, continuously tumbled during and after electric drying, to a large extent dry wrinkle free. Thus, such flat pieces as bath towels, face towels, and even some sheets and pillowcases retain a fluffiness preferred by many housewives to the harder finish resulting from ironing. Saves labor—and, for some clothes, a much more satisfactory finish.

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Of particular interest for decorative purposes are four extra-long, extra-slim fluorescent lamps. Each is equivalent in total light output to a standard 40-watt fluorescent lamp. But instead of being 48 inches long these "slim lines" are 3½, 5, 6, and 8 feet long. They are also smaller in diameter. They are of the instant-starting variety and require no special starter. . . . For use where incandescent lamps are exposed to view, a new lamp is available with a translucent ceramic coating on the entire glass surface that makes the whole bulb the light source, at a slight decrease in efficiency. Wall fixtures in the home, such as beside the mantlepiece, can benefit from such a lamp. . . . The Sterilamp has appeared in a form suitable for wall mounting in living rooms, bathrooms, and offices. The ultraviolet rays help against the spread of colds, flu, and similar communicable diseases. Energy consumption of the bactericidal lamp is negligible.

AIRCRAFT CARRIERS

with their swarms of fighter planes have been dealing devastating blows to the enemy in the Pacific. Brought to high perfection as fighting units in this war, the carrier is the summation of the most advanced engineering. For these vessels Westinghouse has provided powerful propulsion machinery, generating equipment, control apparatus, new-type airplane elevators, and much other machinery. (U.S. Navy Photo)