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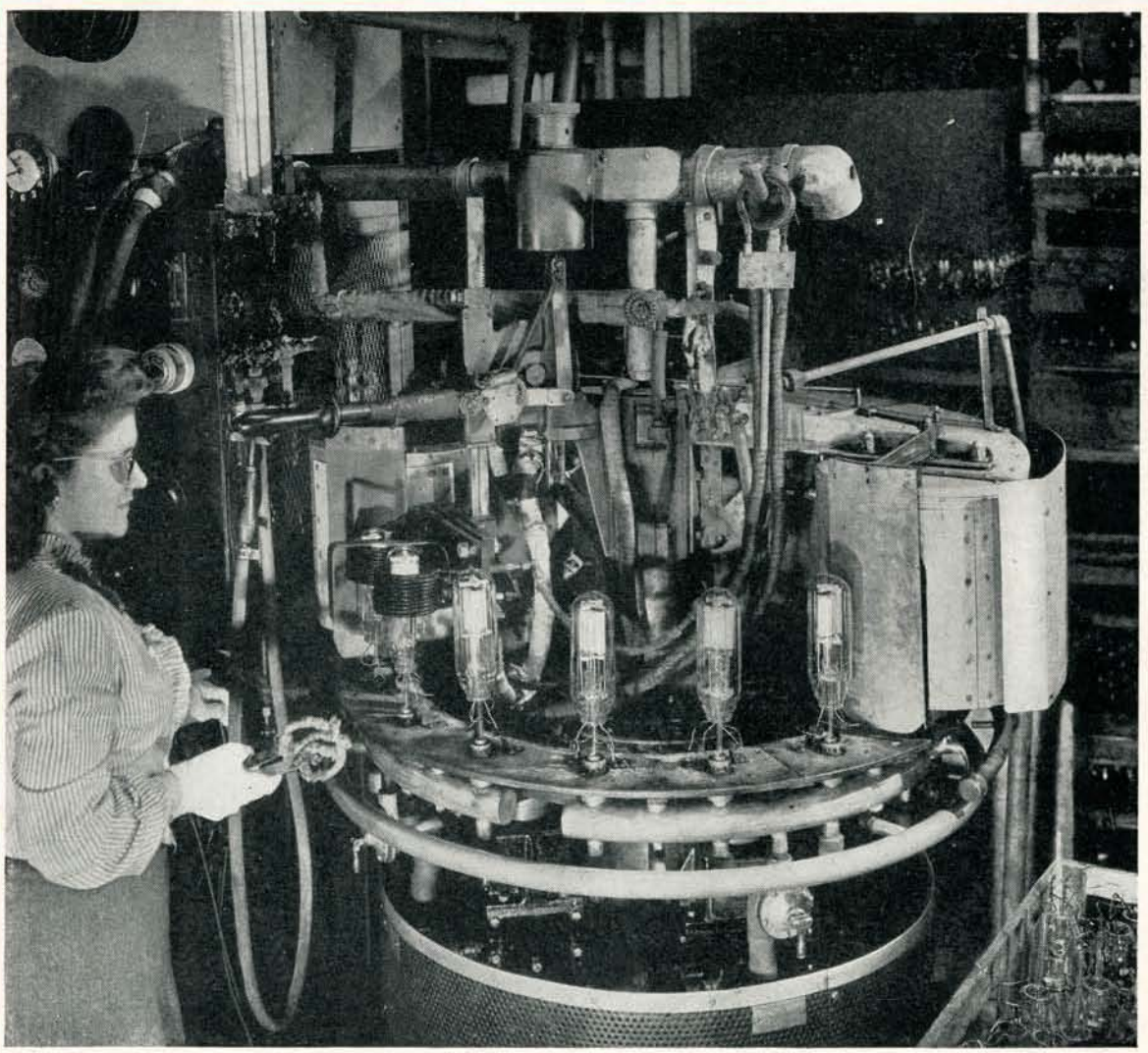

Electronic Eyes, Ears, Brains . . . See page 1

The Story of ELECTRICITY AND ELECTRONICS

Anniversary Issue
No. 7

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Our Cover: In the days of World War I, removing the gas from a vacuum tube required long and painstaking effort on the part of artisans skilled in the craft of glass blowing. Today semi-automatic mechanisms—the one illustrated was evolved several years ago—perform the same job in a twinkling, exhausting hundreds of uniformly processed tubes each working day. Vacuum tubes, in a multitude of forms, serve as eyes and ears and even brains in military and industrial applications. Photo courtesy Western Electric Company.

SCIENTIFIC AMERICAN, July, 1945. Vol. 173, No. 1. Owned and published by Munn & Co., Inc., Orson D. Munn, President; I. Sheldon Tilney, Vice-President; John P. Davis, Secretary-Treasurer; A. P. Peck, Assistant Secretary; all at 24 West 40th Street, New York 18, N. Y. Entered at the New York, New York, Post Office as second-class matter June 28, 1879, under act of March 3, 1879. Additional entry at Orange, Connecticut. Published monthly by Munn & Co., Inc., 24 West 40th Street, New York 18, N. Y.

Previews of the Industrial Horizon

By A. P. Peck

DEFROSTING BY ELECTRONICS

ELECTRONS first came to the aid of the food industry by powering compressors for quick-freezing; now they are serving a new purpose on the other end of the food line—defrosting those same foods in a matter of minutes instead of the hours formerly required. To the housewife the matter of defrosting frozen foods may seem of little moment. To bakers and other users of large quantities of frozen fruits, berries, eggs, and so on, however, the time element becomes important. Not only that, but it is reported that large blocks of frozen foods decrease in taste- and food-value when permitted to thaw slowly at room temperature.

The way in which electronics is solving this problem, according to authorities of the Great Atlantic and Pacific Tea Company, is by means of the well-known and widely used industrial process of dielectric heating. Simply by placing the frozen materials between the plates of a dielectric heating unit and turning on the high-frequency current, defrosting is accomplished quickly, economically, and effectively.

WHICH MODULATION?

STANDARD broadcasting methods, employing so-called amplitude modulation, permit operation of only about 900 stations in the United States. A greater number of wavelengths than this would create confusion comparable with that of the early twenties. On the other hand, frequency modulation, tried and proved during the past five years, would permit operation of some 2000 to 5000 stations in that part of the spectrum now assigned to it. The seeming paradox is due to the property of frequency-modulated waves of reaching only to the optical horizon—usually under 100 miles.

In this limited range of FM is to be found one of its greatest advantages for the furtherance of the things that only radio communication can give to the public. Local stations, providing the same sort of local service as the small-town newspaper and having vast influence in the community, can make use of FM in a way that would be impossible with amplitude modulation. The FM transmissions are free of interference; thus with this system it becomes possible to have a local radio station in every community in the United States with a population of over 2500.

Of course, the great radio chains, using AM, cover vastly more territory than is possible with FM. Their income is dependent upon this great coverage. At the same time, however, they cannot give time to subjects of primary importance to local communities except during the daylight hours when audiences are naturally limited. If the chains would take full advantage of the golden opportunity before them, they will tie in with local FM stations. In this way they would not only meet competition but would broaden their own systems and give an even better public service than the excellent one which they are providing today.

MOTION STUDY

TIME and motion studies are all too often linked with slave-driving proclivities on the part of the employer. As a matter of fact, they should be considered in the light of overall benefactions—to employer and employee as well. When a worker's methods of operation are changed as the result of time and motion studies, he not only does more work and produces more, but at the same time he accomplishes his labors with greater comfort and less fatigue.

Now comes a new angle of motion study. Initially it is being applied to determine the size and design requirements of home units—kitchen, bathroom, dressing room, and the like. These studies are an attempt to fit the home to the individual rather than the individual to the home. Their purpose is to make the greatest use of space for a given requirement and thus reduce to a minimum the losses that go hand-in-hand with room design based on tradition rather than on science.

From this new form of motion study, carried out photographically and then transferred to three-dimensional models, industry can learn a lot. Empirical placing of machines and equipment can give way to a scientific placement method that will allow more workers to occupy a given space comfortably or, on the other hand, a given number of workers to use less space with increased efficiency. With reconversion already well under-way, consideration of truly scientific motion studies can mean the important difference between profit and loss.

ELECTRONIC DUSTING

LOOMING on the horizons as something that industry has ready for the housewife is what has been called "automatic dusting." Actually, it is a part of an air-conditioning system that, by electronic means, precipitates all dust particles in the air introduced into the home and hence reduces the dusting chore to a minimum. It is said that the "automatic duster," by removing dust from the air before it has a chance to settle on furniture, makes it unnecessary to dust the equipped home more than once a month.

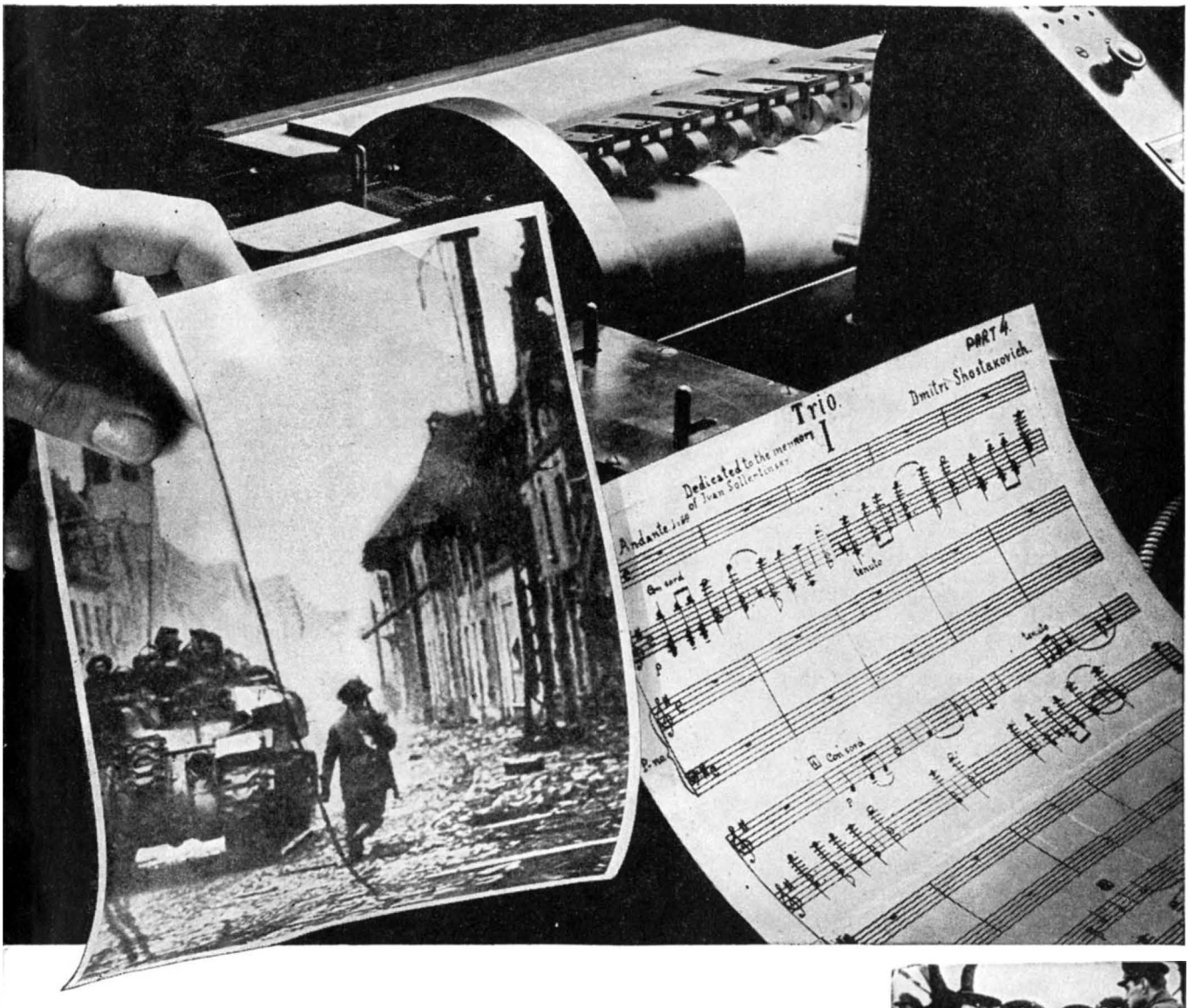
This equipment is no dreamer's vision. For many years it has been salvaging valuable dusts in industry, protecting delicate parts and materials from foreign particles, and abating the smoke nuisance. Now it is ready to go to work in the home, bringing even more leisure to the housewife.

PRE-PACKAGING

PACKAGING improvements have reached a new high as a result of the war, and automatic machinery has been developed that will give faster production, save floor space, and economize on wrapping material. Side-by-side with these advances is coming a realization that many bulk products to be offered for sale to the public can be more readily sold if they are attractively wrapped ("pre-packaged" is the word being used) at the point of production rather than done up in paper after sale. Trials so far reported indicate substantial sales increases coupled with faster sales service.

FOR FUTURE REFERENCE

TELEVISION, just about to turn the oft-mentioned corner, is attracting the attention of Hollywood, with movie producers reported as lining up all television possibilities for exploitation. . . Radar's most important implications are that it is now possible to produce, with high power, those interesting radiations lying between light and radio as radio was known post-war. . . Electronic vulcanization of rubber, producing heat uniformally throughout, promises far superior rubber articles than were ever possible before. . . Correct lubrication of machinery, even by unskilled labor, will be possible by a new color system recently developed. . . A new vitamin that reportedly relieves certain types of stiffness in joints and muscles is made from milk and molasses. . . The air transport industry states that it will need four times as many planes post-war as it now uses. . . "Highly favorable" results in rejuvenating nearly exhausted oil wells have been obtained by pressure-pumping water into the oil-bearing strata, thus literally squeezing out the remaining crude, whereupon it can be pumped to the surface.



Radiophoto – news pictures out of the air!

1945—London to New York—7 minutes

1926—New York to London—1 hr. 35 mins.

Notice the great improvement in clarity, as well as in speed—both results of RCA research. Radiophoto prints are no longer blurred by a "pattern." Today, they're about as clear and sharp as the original photograph snapped thousands of miles away.

RCA radiophoto transmits pictures halfway around the world and prints them—*in a matter of minutes!*

And thanks to RCA research, pictures now come through the receiver (shown above) just about as sharp and clear as the originals themselves.

Through RCA radiophoto, today's "news shot" in Honolulu or Cairo can make tomorrow morning's front page. Or—blueprints for a disabled power generator can be flashed to London—saving hundreds of vital war production hours.

Advertisements, fingerprints, documents and letters are radiophotoed by RCA Communications—as many as 2000 a month! Even musical scores—such as the new "Trio" by the great composer Shostakovich—are sent by faster, error-proof radiophoto.

RCA has long been a pioneer in all fields of international communications. Progress is constantly maintained by scientific research . . . research that is reflected in all RCA products.

When you buy an RCA radio, or television set, or Victrola—made exclusively by RCA Victor—you enjoy a special pride of ownership in knowing that you possess one of the finest instruments of its kind that science has yet achieved.

RADIO CORPORATION of AMERICA

PIONEERS IN PROGRESS

RCA

50 Years Ago in . . .

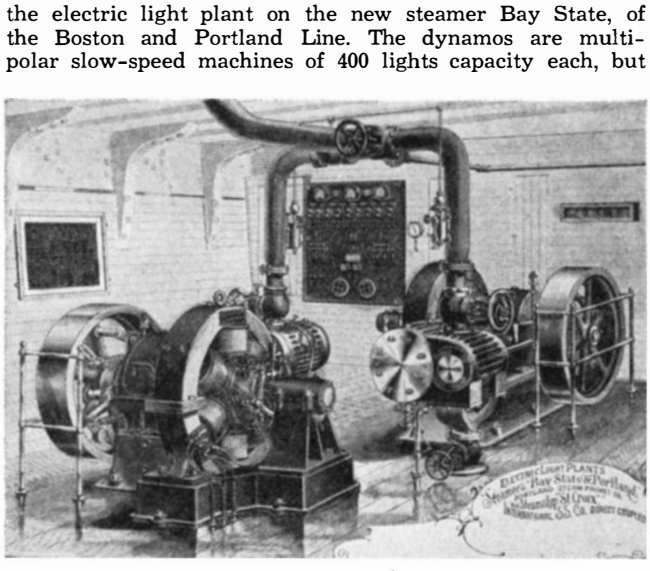
SCIENTIFIC AMERICAN

(Condensed from Issues of July, 1895)

ELECTRICAL POWER — "The electrical industry is about 17 years old and employs over $1,000,000,000 of invested capital. The greater part of this immense investment has been made since 1888, when the electric motor was proved to be a success."

STONE — "Stone, like lumber, requires seasoning. Stone is often spoken of as the synonym of solidity—'as solid as a rock,' we say, but, as a matter of fact, stone is very far from being solid. A cubic foot of the most compact granite, for instance, weighs about 164 pounds, while a cubic foot of iron weighs 464 pounds. This plainly shows that in between the atoms which compose the mass of the most enduring stone there exists much space for air, moisture, and so on. . . . The seasoning of stone prior to use for building purposes has been well understood by the architects of all ages, but in the modern rush of nineteenth century building too little attention has been paid to it. Now it enters into the calculations of every good architect."

SHIP LIGHTING — "The accompanying illustration represents the electric light plant on the new steamer Bay State, of the Boston and Portland Line. The dynamos are multipolar slow-speed machines of 400 lights capacity each, but



either machine will carry the entire load, amounting to 540 lights. . . The dynamos were designed by Mr. W. H. Chapman, electrician for the company. . . The fixtures are of the latest design, with opalescent globes and shades. The dining saloon is fitted with ground glass globes, which gives this part of the boat a very pleasing effect."

STEAM POWER — "Some time ago the Ohio Steel Company, of Youngstown, O., not being able to generate sufficient steam with the boilers already constructed, and not wishing to wait for the completion of those in course of erection, obtained six locomotives from the N. Y., L. E. & W. RR. Co.'s round house, and, placing them side by side at the rear of the engine house, connected them up to supply steam to the extent of 600 horse power."

LIGHT BUOYS — "Incandescent electric lamps on spar buoys have been experimentally used in New York Bay for several years, but an installation has now been completed which marks a considerable advance in maritime engineering and renders the entrance to New York Harbor possible for the largest vessels at any hour of the night. Gedney's Channel . . . is now lighted by 10 incandescent lights of 100 candle power each. The lamps are mounted on 50 foot cedar buoys which are shackled to 5,000 pound mushroom anchors. The cable is constructed of a copper conductor, insulated with gutta-percha, then bedded with jute and sheathed with an armor of hard drawn copper wires. This cable carries successfully a pressure of 1,000 volts alternating current under water for the distance of 6½ miles."

PAPER — "Adansonia bark is chiefly used for the preparation of strong wrapping papers, cartridges, and emery paper. In point of strength the fibers obtained from it are only surpassed by those from the mulberry bush. Papers made with an addition of adansonia fiber not only possess greater tensile strength, but offer greater resistance to tearing."

AVIATION — "It is proposed to include an international exhibition of aeronautical apparatus among the interesting features of the Paris Exposition of 1900. The sub-committee on aerostation in charge of the matter are making preparations for the admission of balloons of all kinds, flying machines and soaring apparatus of every description."

TROLLEY LINES — "Electric lines now connecting with the business center of Chicago, either completed or under way, give a grand total of 500 miles. The benefit of such transportation facilities to a city can hardly be overestimated for the speed of travel will average nearly eight miles per hour or twice that of horse car lines. . . . The operation of the trolley lines is almost perfect, as the cars run smoothly and without delay, there being very few accidents to persons or machinery."

AUTOMOBILES — "Since the early days of the present century a practical road carriage which should carry its own means of propulsion has engrossed the attention of many inventors. Today we are treated to a spectacle of an automobile carriage with four passengers which can travel 750 miles at the rate of nearly 16 miles an hour."

POWER TRANSMISSION — "The first practical demonstration of the system of transmission to be employed by the Cataract Construction Company in carrying the electric power to its customers took place June 29. Two thousand horse power was conveyed from the power house to the works of the Pittsburgh Reduction Company, a distance of three-quarters of a mile."

WOOL CLEARING — "The employment of naphtha as a cleansing substance in the scouring of wool is a new method favorably commented upon by the scientific papers. By the use of a pump the naphtha is forced through and through the wool, extracting all the natural oil, it being also claimed that the naphtha does not injure the fiber of the wool, as does alkali cleansing, but leaves the fleece in an actually better condition than when cleansed by any other process."

WIRE ROPE — "While conducting a series of tests with a 100 ton testing machine at the Yorkshire College in England, which included the testing of a steel wire rope, Prof. Goodman stated that such ropes were not a modern invention, and that he had recently seen a bronze wire rope one half inch in diameter and from 20 to 30 feet long which had been found buried in the ruins of Pompeii and which must have been at least 1,900 years old."

ARC LIGHTS — "In an arc light produced by alternating currents, both carbons are consumed at the same rate and both remain pointed. Carbons burn faster with the alternating current than with the direct."

HOT COOLING — "A fire started in the steamship Massachusetts at the foot of West Twenty-ninth Street, New York City. The outbreak was in the meat storage room in the rear hold, and was caused by the friction of two large electric fans which are used to keep the meat cool."

TELEPHONE SIGNAL — "A small electric lamp is being used instead of a bell in some telephone exchanges in England. The call for connection lights the lamp."

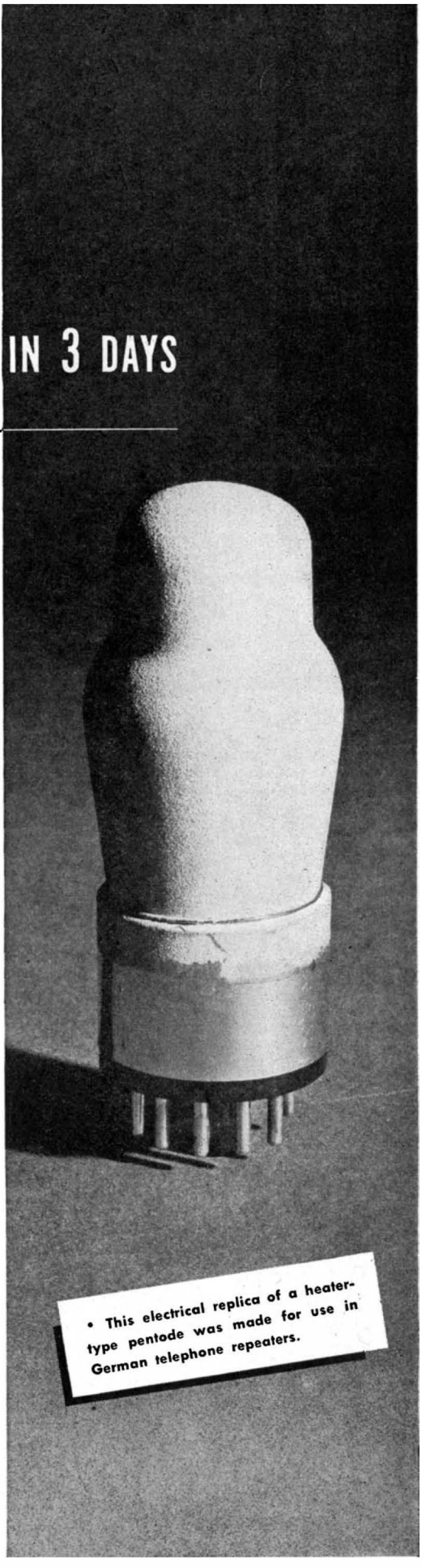
DUPLICATING A GERMAN VACUUM TUBE IN 3 DAYS

Just behind the battlefront, a telephone system lay dead. The retreating enemy, hoping to return, had not blown it up, but had taken with them its vacuum tubes. To put it back to work, the General ordered 1000 new tubes — spot delivery.

A sample tube was flown back to the United States and brought to Bell Telephone Laboratories. It was of German design, different from any American tube in both dimensions and characteristics. Could it be duplicated soon? The job looked feasible. Within three days, try-out models were on their way to Europe. Three weeks later, Western Electric Company had made and delivered every tube. They were plugged in; vital communications sprang to life.

Vacuum tubes are an old story for Bell Laboratories scientists. Back in 1912 they made the first effective high vacuum tube. Three years later, they demonstrated the practical possibilities of tubes by making the first radio talk across the Atlantic, pointing the way to radio broadcasting. Since then, they have developed and utilized the vacuum tube wherever it promises better telephone communication — there are more than a million in your Bell Telephone System.

Today, Bell Telephone Laboratories is solving many of the toughest tube problems faced by the Armed Forces. When the war is over, it goes back to its regular job—keeping American telephone service the best in the world.



• This electrical replica of a heater-type pentode was made for use in German telephone repeaters.

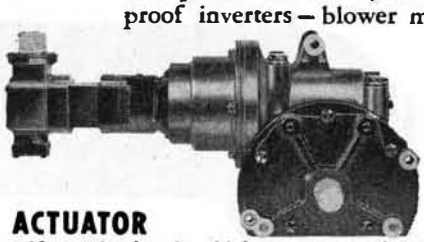
BELL TELEPHONE LABORATORIES

Exploring and inventing, devising and perfecting for our Armed Forces at war, and for continued improvements and economies in telephone service.

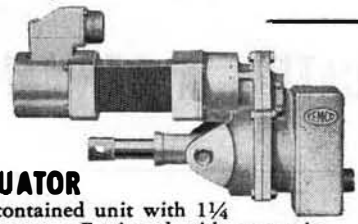
SPECIALLY BUILT ELECTRIC MOTORS

SPECIAL DESIGNS FOR SPECIAL DUTIES
From 1/32 hp to 100 hp

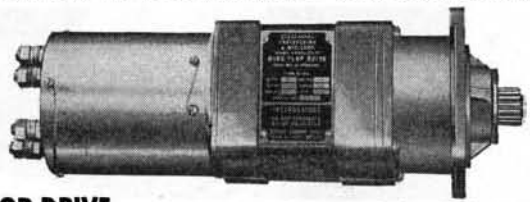
Electric motors — motor drives — linear and rotary actuators — control motors — synchronous motors — self-contained clutch and gear reduction motors — speed increasers — right angle drives — pump motors — submersible motors — splash proof and explosion proof motors — dynamotors — generators — instrument drive motors — splash proof inverters — blower motors — fan cooled motors — self synchronous motors.



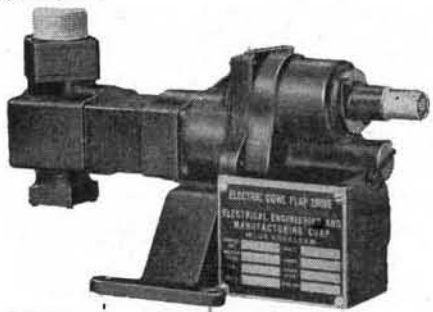
ROTARY ACTUATOR
Completely self-contained unit — ⅛ hp motor, equipped with magnetic clutch and brake — Compound planetary and worm and sector gearing provides a reduction of approximately 15,000 to 1 — Maximum torque on the drive shaft is 6,000-inch-pounds. Can be wound for use in a 28 volt or 32 volt system — Output speed is 5/10 rpm.



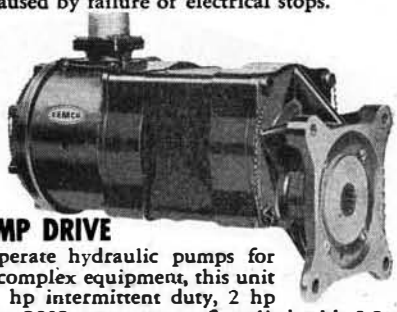
LINEAR ACTUATOR
Completely self-contained unit with 1¼ hp, 10,000 rpm motor — Equipped with magnetic clutch and brake — A double integral gear reduction unit operates screw jack actuator providing 2½" travel on the jack in less than 2 seconds, with maximum load of 3000 pounds — a control gear reduction drive turns cams for opening and closing specially developed limit travel switches.



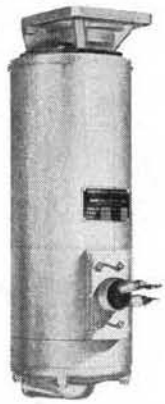
MOTOR DRIVE An intermittent duty type, 2 hp, 7500 rpm motor — Equipped with magnetic clutch and brake — Thermally protected — Additionally protected against exposure to dust, sand or salt spray — Designed for low impact torque, to prevent damage in the event of overtravel caused by failure of electrical stops.



MOTOR DRIVE Thermally protected, ⅙ hp motor — Equipped with magnetic clutch and brake — Motor actuating unit complete weighs 4¾ pounds (nearest competing weight in a motor of this type is 7 pounds) — Shaft output is 8-inch-pounds at 1200 rpm — Straight 8 to 1 gear reduction is provided for work actuation of various kinds — Double reduction and worm drive operates cams for limit motion control.



ELECTRIC PUMP DRIVE
Designed to operate hydraulic pumps for power driving complex equipment, this unit consists of a 3 hp intermittent duty, 2 hp continuous duty, 9000 rpm motor — Supplied with 3.8 gear reduction — Standard AN take-off flange, and female spline take-off shaft — Weight, complete, is 12.4 pounds.



FOR PURPOSES OF INQUIRY — EEMCO engineers will gladly study all problems submitted. Please give them pertinent data regarding desired performance and operation. Cover description of application — duty cycle — kind of current — horsepower — speed — motor dimensions — mounting requirements, etc.

RIGHT ANGLE BLOWER DRIVE
Light weight, continuous duty type, ½ hp, fan-cooled, 7000 rpm motor equipped with right angle gear box and drive shaft — Gear ratio of 1 to 1 — Overall efficiency of 70 per cent — Built for use in a 28 volt system — Engineered to fit extremely tight mounting conditions — Lifetime motor lubrication.

Motor designs to fit work and installation specifications as well as operating conditions — custom motor designs for aircraft — for ships — for trains — for industry — for production — for power. Submit your problem jobs to EEMCO engineers. Let the design experience of EEMCO give you motors tailored to the work for maximum efficiency, for maximum economy, for minimum trouble.

Sealed VAPOR PROOF MOTOR
Double enclosed 2½ hp d-c continuous duty motor — integral gear reduction of 3.8 to 1 is provided — Approximate output rpm is 2400 — Overload capacity is 150 per cent for 15 minutes — 32 or 110 volt d-c — An internal fan cooling system is an integral part of the unit.

SPLASH PROOF INVERTER
Self contained unit designed to convert 32 volt d-c current into 110 volt 60-cycle a-c current — Totally enclosed, fan-cooled model with 350 volt amperes peak capacity — Can be adapted for use with a power supply source of 110 volt d-c.

EEMCO

ELECTRICAL ENGINEERING AND MFG. CORP.
4606 West Jefferson Boulevard, Los Angeles 16, California

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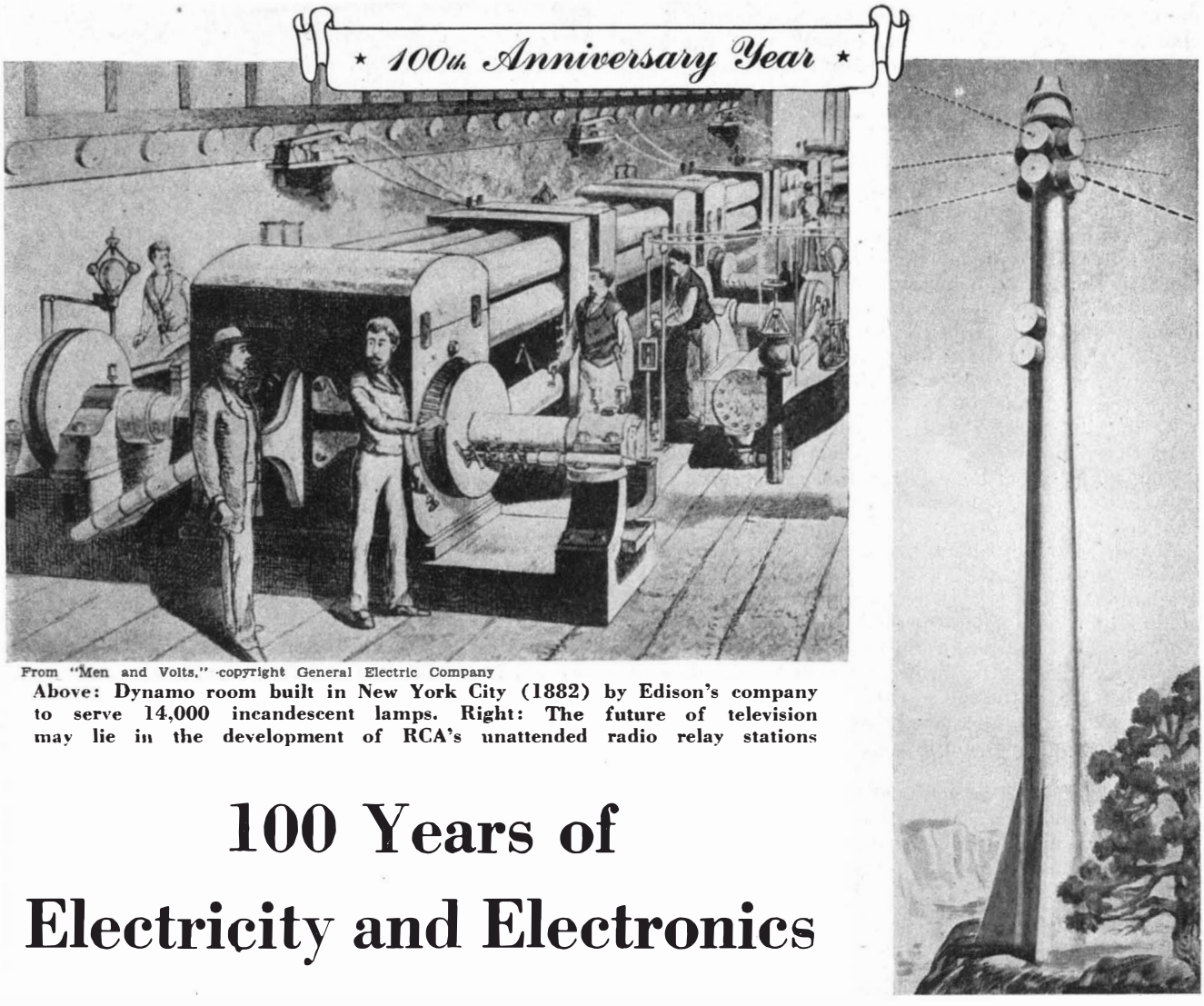


From "Men and Volts," copyright General Electric Company

Above: Dynamo room built in New York City (1882) by Edison's company to serve 14,000 incandescent lamps. Right: The future of television may lie in the development of RCA's unattended radio relay stations

100 Years of Electricity and Electronics

Less than the Span of a Single Century Covers the Lifetime of Applied Electricity. From Early Developments in an Obscure Art has Come the Science of Electronics, Taking Over Many Jobs in Industry and Doing Them Better than Ever Before. A Glimpse of the Future

By **VIN ZELUFF and JOHN MARKUS**

Associate Editors, ELECTRONICS

GOING BACK a hundred years, just beyond the memory of anyone living today, brings us simultaneously to the first issues of Scientific American and to the growing-pains days of electricity, when glowing electronic tubes were yet undreamed of and even the electron itself was unknown.

In 1845, horses furnished the motive power for transportation. The life of these horses was rigorous, and on the average they lived only about three years. As evening approached, lamplighters made their rounds through city streets on nights when there was no full moon. In homes the filling of kerosine lamps, trimming of wicks, and wiping of the glass chimneys was an almost daily chore. This non-electrical kind of living continued for just about 35 more years, while scientists and inventors plodded away in dingy laboratories creating the electrical foundations for the progress to come.

Even in 1880 there were no electric lights, except in the hands of a few experimenters—no electric streetcars except in the dreams of visionaries—no electricity in homes, and little anywhere else. But people did not miss these things; in fact, visitors at the Centennial Exposition in 1876 glanced at the small and unobtrusive Gramme generator supplying current to a single arc lamp and blinked at the dazzle of bluish light. "What curiosities!" they commented as they walked on to admire the giant steam engine in the next booth.

But the inventive minds of men like Brush, Thomson, and Edison kept prodding these first sputtering dynamos into more and more of the productive uses that would one day compel the steam engine to share honors with electrical power. Brush improved on the dynamo and made the carbons of the arc lamp adjust automatically to the correct distance apart, without touch of human hands. The first Brush lamps to be installed in Philadelphia, in the show windows of the John Wanamaker store, were one of the wonders of 1878 and were de-

scribed by one newspaper reporter as "miniature moons on carbon points, held captive in glass globes."

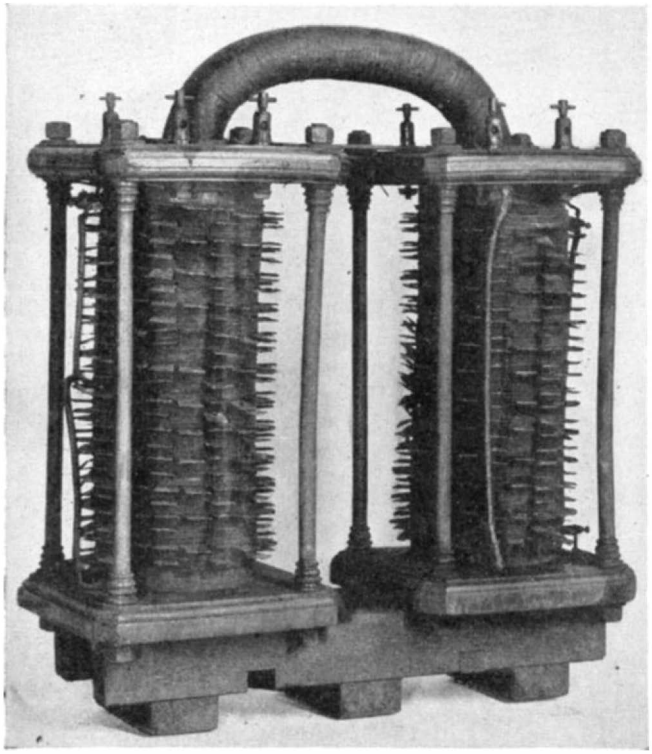
ARCS TOO BRIGHT—Elihu Thomson made the generator brushes adjust themselves automatically to changes in load, so that individual lights could be switched on and off without upsetting the balance of the circuit. But the arc lamp was too bright for home use and had many other weaknesses. Could anyone cut up its two thousand candlepower into, say, twenty lamps each equal to a hundred candles?

Thomas A. Edison thought he could. Near the end of October in 1879 he carbonized a cotton thread, bent it into a horseshoe shape and put it inside a sealed glass bulb. The current was switched on. The lamp glowed with a soft light. Half expecting the frail red horseshoe of light to vanish, he and his workers sat down to watch and wait. No one thought of eating or sleeping. A second dawn found them still at their vigil, and not until 40 hours after that lamp first received current did it burn out.

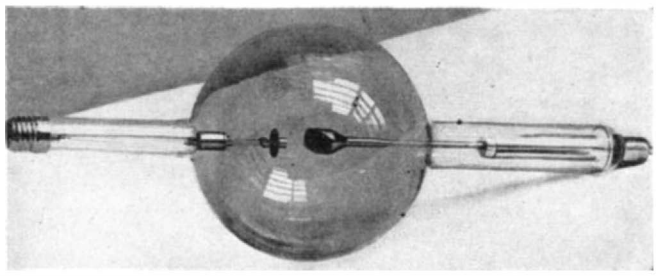
As the little lamp glowed on and on, they envisioned great cities lighted from central power stations by lamps lasting hundreds of hours. They had a lamp that could go where arc lamps were impractical—an entirely new light source to compete with gas lighting.

In city after city in the decade that followed, elaborate celebrations heralded the turning on of outdoor arc lamps for the first time. People fell on their knees at the sight, as if in the presence of the supernatural. And all this time explorers were searching the world for dense, woody growths from which better filaments could be cut for Edison's lamps. Bamboo of a certain species proved better than anything else then known. In 1881 his company sold nearly 30,000 lamps at 70 cents each.

By August 1882 Edison had wired 900 buildings in New York and placed more than 14,000 lamps in their sockets. But troubles were ever present. During a test of the system, a young man burst into the dynamo room crying: "Your electricity has got into the pavement up in Fulton Street and all the horses are dancing." An Edison crew took several days to locate the faulty buried conductors and repair the insulation that caused such mischief. The system was successful at its inaugural, however, and initiated two decades of exploitation of "dose schmall condensed lights vat comes in bottles," in the words of one newly arrived immigrant.



Forerunner of the transformer was this Gaulard and Gibbs unit brought to U.S. in 1885 by Westinghouse



By 1917, this Coolidge X-ray tube had standardized practice in a field formerly on a hit-or-miss basis

IMPROVING THE PERFECT—By 1900 many scientists were convinced that Edison's carbon filament lamp was just about perfect and doubted whether it would ever be materially improved. However, the General Electric Research Laboratory was started that year, and since then the efficiency of the lamp has been increased about sixfold!

Dr. Whitney started the investigation when the gradual blackening of the bulbs, as they were used, began to annoy him. He knew that the blackening was caused by the evaporation of carbon from the carbon filament, but he thought the rate of the blackening might be increased because the filament contained small traces of ash oxides. To reduce the undesirable oxides, he tried treating some carbon filaments in a special furnace at a much higher temperature. For the same life as prior filaments, his new lamps had 25 percent higher efficiency; at the same efficiency, they had 4¾ times the life!

Whitney's new GEM lamps were put on the market in 1905. (GEM was the name obtained from the initials of General Electric Metallized—so called because the graphite coating of the carbon filament acquired metal-like characteristics in the furnace.) GEM lamps sold for 12 years, when they were replaced by tungsten-filament lamps whose efficiency was 80 percent higher.

Dr. W. D. Coolidge initiated this next advance in lamp efficiency by developing a process for producing ductile tungsten commercially and drawing it down to a fine wire. Lamps with this tungsten filament were so strong that breakage in shipment was no longer a major problem, and the lamps at last were able to withstand the violent shudders of the automobiles of those days.

Dr. Irving Langmuir soon discovered that the blackening of lamp bulbs caused by evaporation of tungsten from the filament could be greatly reduced by filling the bulb with an inert gas at atmospheric pressure. All except the smallest-size bulbs are gas-filled today, and modern lamps generally burn out long before they would have to be discarded due to the blackening effect. The 60-watt bulb that once cost $1.75 and had an efficiency of 1.7 lumens per watt for a useful life of scarcely more than a hundred hours is today selling for only 13 cents yet has an efficiency of 13.9 lumens per watt and lasts more than 10 times as long.

BETTER X-RAYS—As soon as he succeeded in producing wrought tungsten for lamps, Coolidge turned to its application to X-ray tubes. Observing the higher melt-

ing point and heat conductivity of tungsten, he replaced the platinum target of the tubes with tungsten.

Up to this time, all X-ray tubes were dependent for their operation on the presence in them of a small amount of gas, which determined the characteristics of the tube. But, since different degrees of penetration were required for radiographing different parts of the body, X-ray technicians had to keep an assortment of tubes. Even then there was a certain amount of guesswork involved in selecting the right tube.

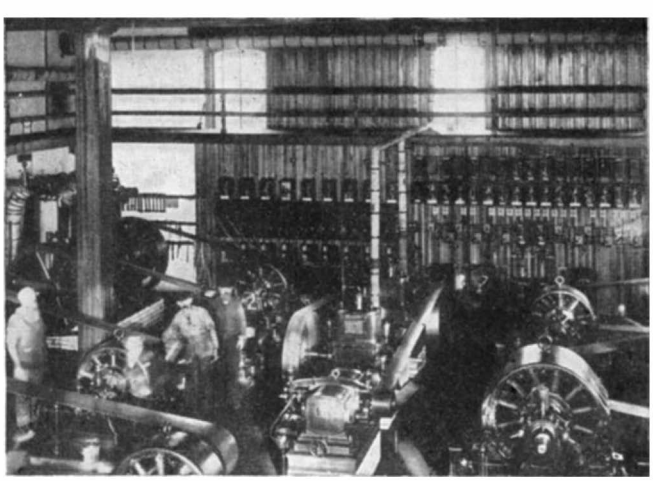
Coolidge planned to build a tube with the highest attainable vacuum and with a hot-tungsten filament replacing the cold aluminum disk as cathode. He reasoned that the electron emission depends on the temperature of the filament, so why not control the temperature of the filament by a rheostat? Coolidge tried, and it worked. By such control, he could determine the electron emission and consequently the electrical characteristics of the tube. This tube, which bears the name of its inventor, has made an exact science of the hitherto hit-or-miss X-ray practice.

Today 1,000,000-volt and 2,000,000-volt X-ray tubes peer through many inches of steel as though it were glass, and scientists are even working on billion-volt tubes.

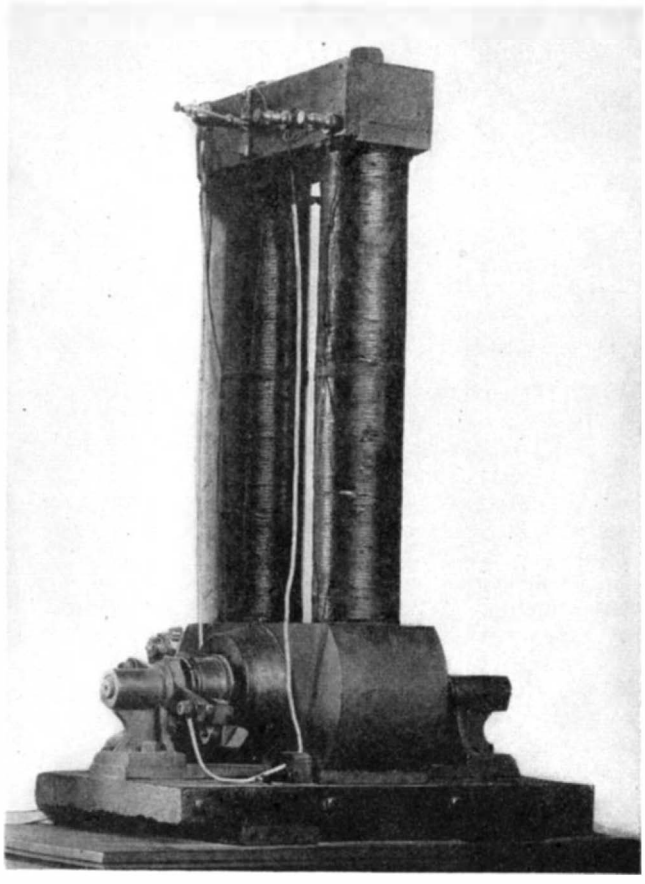
WIRE COMMUNICATION — The telegraph really started with Oersted, who in 1819 found that a magnetized needle would be deflected from its normal position when brought close to a wire carrying a current. Soon after, Ampere proposed the use of magnetic needles and coils for the reception of signals. Ampere's first telegraph system employed a pair of line wires for each character to be sent, which made it of little value.

Wheatstone and Cooke did much to popularize the telegraph and to demonstrate a system of the deflecting-needle type, requiring six line wires. It was used on railway systems, but was superseded by a type having only two line wires.

While returning from a study of art in Europe, Morse designed his first telegraph. Morse had a stylus attached to a movable armature which was actuated by the pull of an electromagnet. The stylus traced a record of the dot and dash code impulses on a moving piece of paper. About 1835, Morse privately demonstrated his telegraph and obtained the backing of Gale and Vail. These men not only obtained financial aid, but also made later improvements. The early sending switch was operated by drawing beneath it either a notched bar or a bar in which pegs were arranged in accordance with a code. Neither hand operation nor aural reception were employed at this time.



An early alternating-current central station, with belt-driven generators and wooden switchboards in rear



First dynamo (Edison) ever used to operate incandescent lamps on a ship. Courtesy U.S. National Museum

Soon Morse and his associates substituted a telegraph key, operated by hand for the early sending apparatus. The method of reading the Morse dot-and-dash code message from sound rather than from a tape was perfected by Vail in 1844.

Morse obtained patents in 1848. As early as 1838 he had demonstrated his apparatus before the President of the United States and his cabinet. Money was provided by the government for the construction of a line between Washington and Baltimore. This line was opened for public use and proved successful. Yet when Morse offered his telegraph to the government, it was refused on the recommendation of the postmaster-general, who stated that he was "uncertain that the revenues could be made to equal its expenditures."

To increase the message-carrying capacity of the line, Gintl invented the duplex system in 1853, and Heaviside in 1873 and Edison in 1874 independently invented the quadruplex system. The multiplex system was suggested by Farmer in 1852, and later developed by Meyer (1873), Baudot (1881), and Delaney (1884).

SUBMARINE CABLES—After the introduction of gutta-percha as an insulator and methods of applying it to wires had been developed, submarine cables became of commercial importance.

One of the first attempts to lay a submarine cable was made in 1850, when a cable was placed between England and France. Because of its weak construction, it broke shortly after communication was established. In 1851 a second attempt was made and this time the cable proved successful.

The first attempt to lay a cable across the Atlantic was made by Cyrus Field and his associates in 1857. It ended in complete failure. In 1858, however, a cable was successfully laid between Newfoundland and Ireland; it was operated for about three months before it failed

in deep water and could not be repaired. In 1865 an effort was made to lay another cable, but it broke when about two-thirds completed. The following year, however, a cable was laid across the ocean, and this cable proved satisfactory. Soon after, the broken end of the cable laid the previous year was picked up, and this cable was then completed. These two cables were operated without competition until 1869, when an additional cable was laid. Now there are more than 20 cables across the Atlantic between North America and Europe alone, and more than 3200 submarine telegraph cables in the entire world with a total length in 1931 exceeding 350,000 miles.

WIRELESS—In 1865, James Clerk Maxwell, utilizing the electrical and magnetic experiments developed by Faraday and Oersted, proposed that light waves were electromagnetic in character and that a charge of electricity moving through space constituted an electric current. Heinrich Hertz proved in 1888 by his experiments that Maxwell's predictions were valid. Hertz showed that radio waves move with the same speed as that of light and behave in much the same manner. He also showed that the radio waves had lengths that varied from a few inches to many miles.

With Hertz's equipment, electric waves could be detected at very short distances only. During the early nineties, however, many scientists, including Branly and Lodge, experimented with a more sensitive type of detector, to which the general name coherer was given. This instrument consisted of a glass tube containing two metal plugs with a large number of small metallic particles placed between them. When electric oscillations were passed through the coherer, the particles adhered together, and the resistance dropped. To use the instrument for the continuous detection of groups of oscillations produced by operation of the hand key it was repeatedly tapped by a hammer like that of an electric bell. This unit was called a decoherer.

With an instrument of this nature, Marconi received signals sent by electric waves over distances of several miles, and he found that the addition of an antenna system increased the range of his equipment.

The next major discovery in the field of wireless was due to Sir Oliver Lodge, who realized the importance of tuning the circuits to make them all resonate to the particular frequency of the oscillations which it was desired to send out. He did this by adjustment of the size of the coils and condensers employed. As a result of the improved sensitiveness thus attained, Marconi, in 1901 was able to detect signals in Newfoundland sent out from Cornwall, England.

In England, spark transmission was improved by the introduction of the Marconi rotating spark gap, which both decreased the rate of decay or damping of the oscillations and gave a musical note in the telephone receiver. In Germany, the Telefunken Company developed the quenched spark system, in which the same objects were achieved by means of a specially designed stationary spark gap.

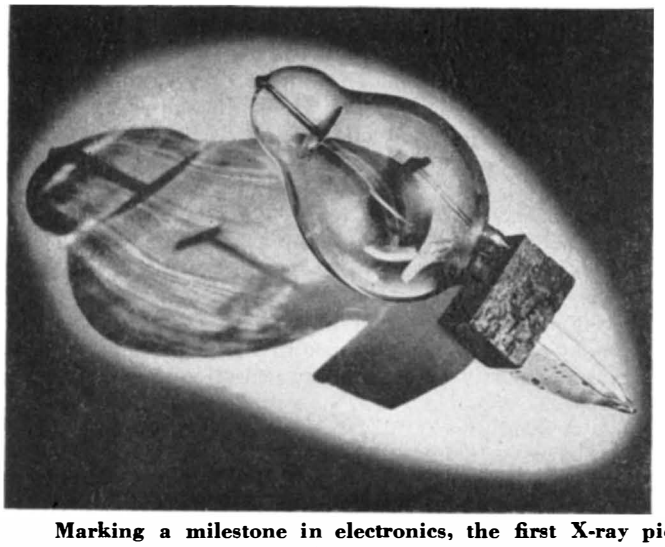
By 1912 the Marconi Company was conducting a commercial service between Clifden in Ireland and Glace Bay in Canada, and at the beginning of World War I a 300-kilowatt spark station had been completed near Carnarvon for communication with the United States. The development of radio communication between ships at sea and between ships and shore was also far advanced, and the number of lives saved by wireless at sea was already large.

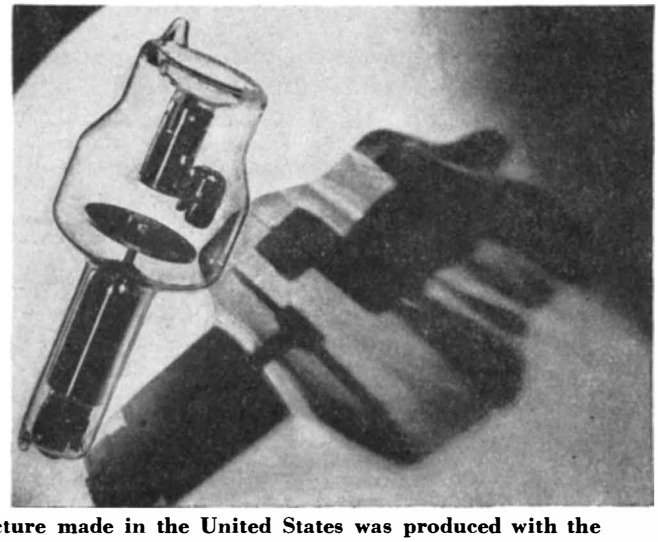
Poulsen and Pedersen in Denmark developed to a considerable extent the Poulsen arc system of transmission, in which the aerial was connected to one side of an electric arc, the other side being connected to the earth. The arc system was further developed in America by C. F. Elwell, and many of the high-power arcs were installed in stations in Europe. In addition to the arc system, the design of high-frequency alternating current machines was carried to an efficient stage of development, especially by Latour in France and by Alexanderson and Goldschmidt in America. These machines were installed in many French and American high-power stations.

The sensitivity of the detectors of radio waves, the crystal and coherer, was very small and the search for a better instrument to convert the received energy efficiently led to the development of the vacuum tube.

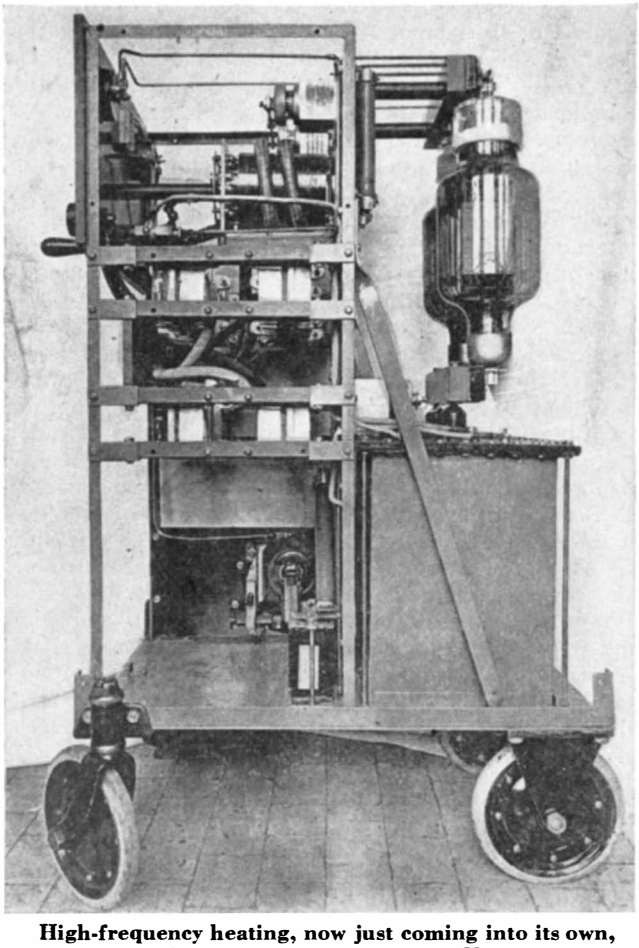
EDISON EFFECT—In 1883 Thomas Edison, while conducting experiments with the incandescent lamp, noticed that if a second electrode in the form of a wire or plate was placed inside the lamp and this electrode made positive with respect to one end of the filament, a small current flowed to this electrode when the filament was heated. This is called the Edison effect and is the basis of modern electronics.

Professor J. A. Fleming of England learned of the Edison effect, and about 1896 developed a two-element radio detector tube which became known as the Fleming valve. About 1906, Dr. Lee de Forest added a third electrode, called a grid, to the vacuum tube. The vacuum





Marking a milestone in electronics, the first X-ray picture made in the United States was produced with the tube at the left above. Compare this with the modern rotating-anode tube (right) from Machlette Laboratories



High-frequency heating, now just coming into its own, was done 25 years ago with this Ajax-Northrup unit

tube was improved by further study and experimentation carried on by Dr. Langmuir and other scientists, and today there are about 1000 types in use in our radio and electronic equipment.

Mention must be made of the extremely successful experiments in radio-communication carried out by amateurs, which went a long way to show commercial engineers that possibilities were being overlooked in the short-wave region. Just prior to World War I, amateur stations which had previously been allowed longer wavelengths were subjected to a degree of control, and forced to rely solely on wavelengths below 200 meters, then considered useless for serious purposes. After the most commendable persistance and endeavor, amateur signals were first received in England from America in 1921 on wavelengths slightly below 200 meters, and by 1924 communication in both directions on shorter wavelengths and very low power had become frequent. It may be said that short-wave communication was both discovered and to some extent developed by those working essentially for the fun of it and for the advancement of science, without thought of immediate material gain.

In 1916, David Sarnoff, then assistant traffic manager of the Marconi Wireless Telegraph Company of America, proposed a "radio music box" in a memorandum to his boss: "I have in mind a plan of development which would make radio a household utility in the same sense as a piano or phonograph. The idea is to bring music into the house by wireless . . . For example, a radio telephone transmitter having a range of say 25 to 50 miles can be installed at a fixed point where instrumental or vocal music or both are produced . . . The receiver can be designed in the form of a simple 'radio music box' and arranged for several different wavelengths, which should be changeable with the throwing of a single switch or pressing of a single button . . . The same principle can be extended to numerous other fields, as for example, receiving lectures at home which can be made perfectly audible; also, events of national importance can be simultaneously announced and received. Baseball scores can be transmitted in the air by the use of one set installed at the Polo Grounds. The same would be true of other cities. This proposition would be especially interesting to farmers and others living in outlying districts removed from cities. By the purchase of a radio music box they could enjoy concerts, lectures, music, recitals, and so forth which may be going on in the nearest city within their radius . . . Should this plan materialize, it would seem reasonable to expect sales of 1,000,000 radio music boxes within a period of three years."

Today, as president of Radio Corporation of America, David Sarnoff sees his memo-dream fulfilled and expanded many times, with the vast potentialities of electronics swiftly unfolding from its nucleus of radio.

Thirty years ago, De Forest's three-electrode tube was applied as a repeater on the telephone wire circuits connecting New York and San Francisco, making transcontinental telephony possible and practical. In wire telephony and telegraphy, as well as in radio, electronic applications provide a basic means from which successive developments are made to meet the communications needs of expanding industry and national activity.

Now, radiotelegraph circuits over distances in excess of 5000 miles operate at transmitting speeds of more than 500 words per minute. Electronics has made possible short-wave teletype circuits which reach practically any part of the world and radiophoto services in which pictures taken on the battlefields of Europe or in the Pacific are brought, within a few hours, to our daily newspapers. Regular radiophone service is available to the remotest sections of the globe, and radiotelegraph and telephone services even extend to ships and planes almost anywhere.

Radiograms are not broadcast in the sense that they can be picked up by the general public. Directive aerials project the transmitted energy toward the desired receiving terminal in the form of a concentrated beam, somewhat analogous to the beam of a searchlight. High-speed automatic transmitters are used and the messages can be recorded only by special receiving apparatus. Simultaneous transmission of two or more messages on a single radio channel — known as multiplexing— results in effective scrambling of the radio code message, which can be detected or unscrambled only by special synchronized equipment.

TELEVISION—In the early 1930's there was developed in the laboratories of Radio Corporation of America an all-electronic television system that made use of Dr. Vladimir K. Zworykin's iconoscope, a tube employing electronic scanning to convert the light image into an electrical signal. Development of this system continued in the laboratories for several years, and in 1936 was given field tests. A hundred television receivers were built for installation in the homes of RCA engineers and executives, and a transmitter was installed in the tower of the Empire State Building. The tests were successful, and in 1939 limited commercial television broadcasting was authorized by the Federal Communications Commission.

Other organizations were also conducting experiments during the above period, and there naturally arose some differences of opinion among engineers as to technical details such as the required number of scanning lines, systems of synchronization, and so on.

These differences were reconciled and standards established by a committee of engineers in 1941. The Commission adopted the committee recommendations and authorized commercial television broadcasting to start on July 1, 1941. Had it not been for the advent of the war, television would be well on its way as a national service.

RADAR—From radio and television came radar, used by static ground defenses and on warships to detect the approach of enemy aircraft and ships at night or through cloud cover, to determine the distance (range) to the enemies' forces, and to provide data for anti-aircraft guns.

In the Battle of Britain, equivalent British radio locators spotted German raiders long before they reached a target area, and thus gave the RAF and ground defenses time for preparation. On a stormy night off Guadalcanal on May 31, 1943, one of our ships sank a Japanese battleship miles away with its second salvo, using only radar to direct the guns.

On December 7, 1941, the Army's radar at Pearl Harbor, with Private Joseph L. Lockard on duty, detected planes approaching, and located them about a half hour distant from the Hawaiian Islands. His superior officer, knowing that a number of American planes were due from the mainland, took no action. Although radar's warning went unheeded, its signal summoned America to the most tremendous undertaking in its national history.

Like many electronic inventions, radar is attributed to no one inventor. It draws upon many radio devices and circuits, and therefore many scientists contributed to its development. The basic principle of radar — radio reflection — is as old as radio itself, but it was not harnessed until we had to find an anti-warplane device.

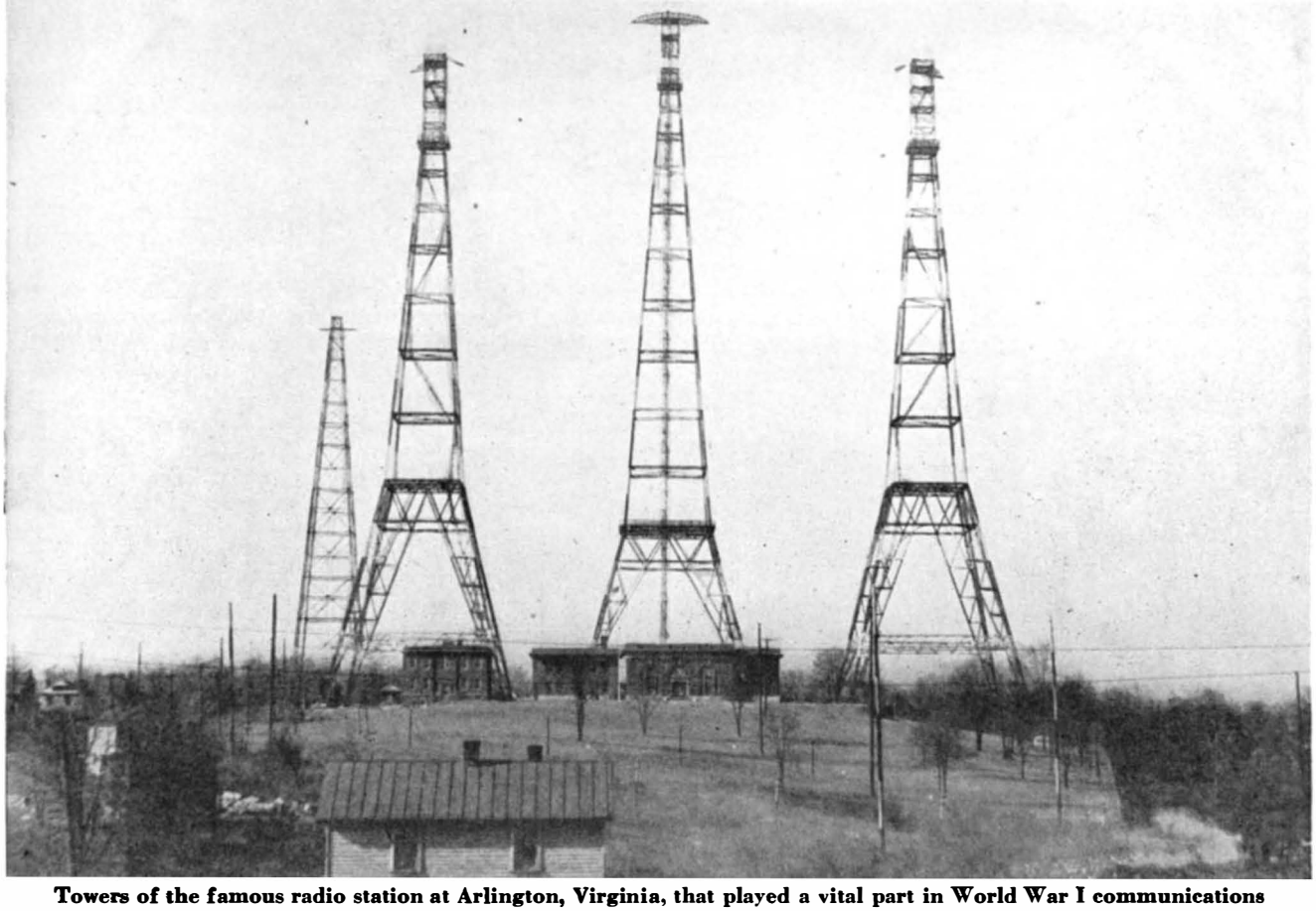
When Hertz demonstrated that electromagnetic waves could be reflected, he was far ahead of his time in radar. But it remained for Tesla to recognize and to point out the practical application of the radio echo:

"I have sent electrical vibrations toward the remote boundaries of the earth, and the earth has replied. In place of an echo I have obtained a stationary electrical wave—a wave reflected from afar. Stationary waves . . . mean something more than telegraphy without wires to any distance . . . For instance, by their use we may determine the relative position or course of a moving object, such as a vessel at sea, the distance traversed by the same, or its speed."

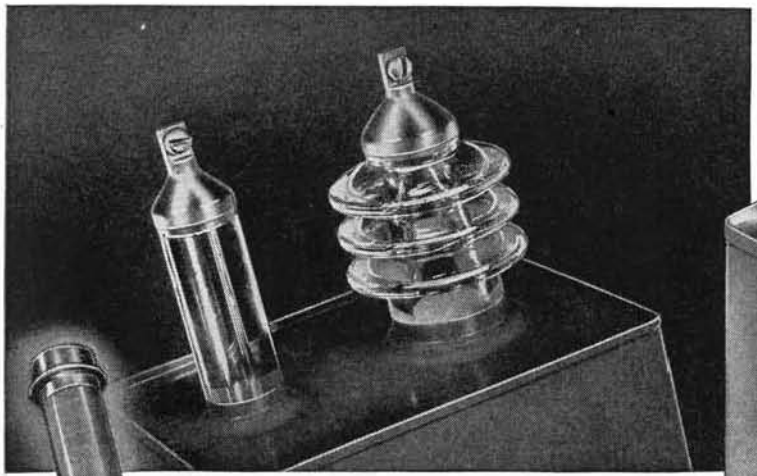
In the battle of Attu in Alaska, when our forces arrived and wanted to get men ashore in small boats, the weather made visibility so bad that the water could not be seen from the deck of a ship. The ships were berthed and the men landed by the use of radar.

A radar-controlled anti-aircraft searchlight, recently displayed by the Army Service Forces, synchronizes the beam of a powerful field searchlight with movements of the target. The equipment requires three operators seated at a tent-covered control board on which are four circular cathode-ray screens. The two large screens or scopes indicate the location of the airplane and the two smaller scopes give the distance or range, in terms of spacing between two bumps or pips in the pattern traced by the electron beam on the screen. A highly mobile concave radar antenna is mounted atop the control board and is simultaneously aimed with the searchlight by means of hand wheels on the control board. When both antenna and searchlight are on the target, the searchlight automatically goes on and its beam intercepts the aircraft.

Other radar equipment recently displayed includes an early model portable radar warning set. Its direction-finding antenna consists of a large number of small wire antenna arranged in a concave pattern to give



Towers of the famous radio station at Arlington, Virginia, that played a vital part in World War I communications



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Sprague engineering progressiveness is no better exemplified than by the three outstanding achievements depicted here. And remember, such developments are only the high spots! Equally important is the fact that similar, if less startling, engineering superiority is evidenced in every one of the hundreds of Sprague Capacitor and *Koolohm Resistor types that are regularly produced. Even small points of departure from the conventional often make a startling improvement in results—and no type or design produced by Sprague is so humble as to fail to receive regular engineering attention in a constant effort to surpass for Tomorrow that which is "best" Today.

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*Trademarks Reg. U. S. Pat. Off.

beam action. With the controls in the portable set are two scopes, indicating the position of the plane in relation to the set. This instrument, now obsolete, was capable of locating a medium bomber up to 100 miles away.

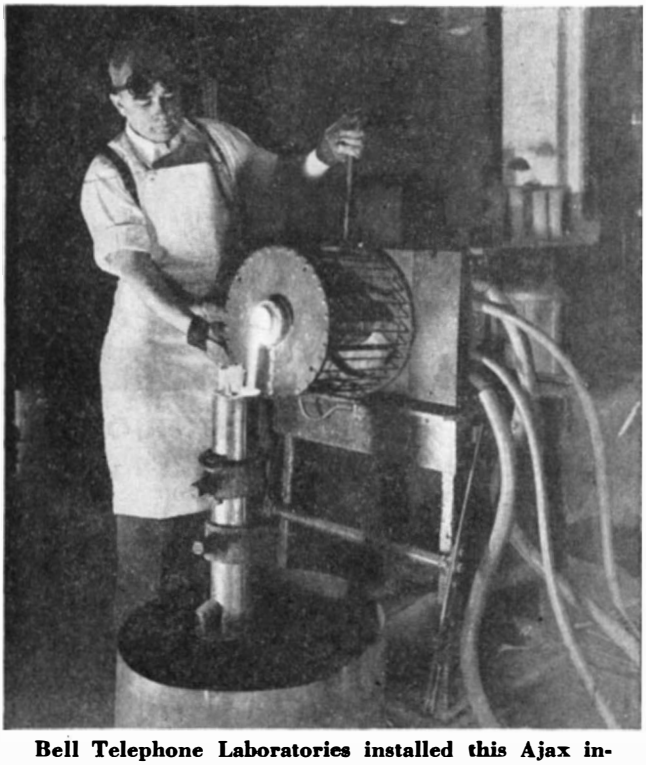
Heavier radar anti-aircraft apparatus automatically controls gun range. This, however, is a massive piece of field equipment. The entire equipment, including the antenna structure and the three operators, moves as a unit and can be turned in all directions.

Revealed at last is the mystery of how Allied bombers have been able to drop their bombs accurately on invisible targets through the thickest clouds, smoke, or darkness. The electronic device that does this is called "Mickey" and is a form of radar that allows airmen to see on the screen of the scope distinctive outlines corresponding clearly to landmarks far below. A trained operator watching the scope can readily distinguish the line between land and water, as required in the bombing of most large cities since they have river or coastal frontage. In effect, Mickey gives a profile of the terrain below, and can be focused to get an increasingly sharper picture of limited areas such as an industrial area or even a specific building.

On D-day in Normandy Mickey enabled bombers to find their beach targets through an overcast and also located landing places for air-borne troops in the darkness. As in radar, a signal is sent back by the invisible target like an echo and is translated electronically to an image that is a reproduction of the ground below. Water shows up as dark patches, while buildings are lighter patches having the same shape as the actual structures on the ground.

Not all planes in a bombing mission need to carry radar, which is fortunate because the equipment is quite bulky and therefore reduces the bomb load. One tactical procedure involves using a pathfinder plane to locate the target by radar and drop on it one or more colored smoke bombs that allow succeeding waves of planes to sight the smoke columns from as far as five miles off and release their bombs over the target.

The letters of the word "radar" spell the same forward and backward, with *ra* standing for radio, *d* for detection, *a* for and, and *r* for ranging. The fact that radar involves a backward reflecting echo is apparently just a coincidence with the reversible spelling.



Bell Telephone Laboratories installed this Ajax induction furnace for experimental alloy work in 1919

Courtesy Westinghouse Electric Corporation

A method of concentrating low-grade ores electronically may prove applicable to other concentration jobs

Although radio-controlled bombs are still in the fantastic-invention category as far as the general public is concerned, the Army Service Forces recently displayed to the press a radio system that is capable of detonating mines at distances up to eight miles on land and up to 20 miles underwater. When the mine is laid it is assigned a definite radio frequency of its own. By means of a telephone dial attached to a radio transmitter, the operator can dial a three-digit number corresponding to that assigned to the mine to be set off. Over 21,000 combinations of code pulses are available for this radio detonator system.

Electronics was born of research. However, many of the more common electronic phenomena were discovered before there was a definite knowledge of the mechanisms involved. X-rays, accidentally discovered at the end of the last century, were so named because Roentgen could not explain the action. Electron emissions were discovered accidentally and independently by Edison and others. Photoelectric effects were discovered in 1887 when Hertz showed that ultra-violet light would lower the breakdown voltage of a spark gap, and it wasn't until 1899 that J. J. Thomson identified photoelectric emissions as electronic in character. Research brought radio, which is at one and the same time the forerunner of electronics and one of the major branches of electronics.

INDUSTRIAL ELECTRONICS—Just as electronics has revolutionized warfare, so has it affected industry. Electron tubes have brought a new meaning to the word "automatic" in mechanical and electrical operations. No task is too heavy, too fast, or too precise for the electron tube. It opens doors, brings elevators to a level landing, operates timing devices, and rings alarms. It is used for smoke, fume, and fire detection. As an electronic eye it analyzes, sorts, weighs, inspects, and detects flaws as well as foreign material; it counts hundreds of items from ball bearings and beans to packages and automobiles, matches colors, gages the

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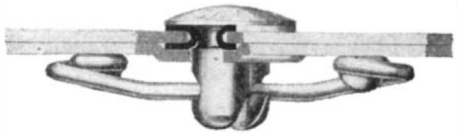

Complete assembly of the Dzus spiral cam fastener

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thickness of materials to a millionth of an inch, and marks time to the millionth of a second. It measures humidity and atmospheric pressure, and controls temperatures. It detects the presence of solids no human eye can see and gases no human nose can smell.

The capabilities of electronics for good or evil depend solely on the morals of those who employ them. The tubes can hear, see, feel, taste, smell, remember, calculate, and talk. They are the electronic brain not only of radio, but of industry. By the use of the electron tube, production is accelerated, power converted, work made more precise, safety enhanced, and machinery and processes controlled automatically, thus offering a wide new field for electronic engineering and electronic devices.

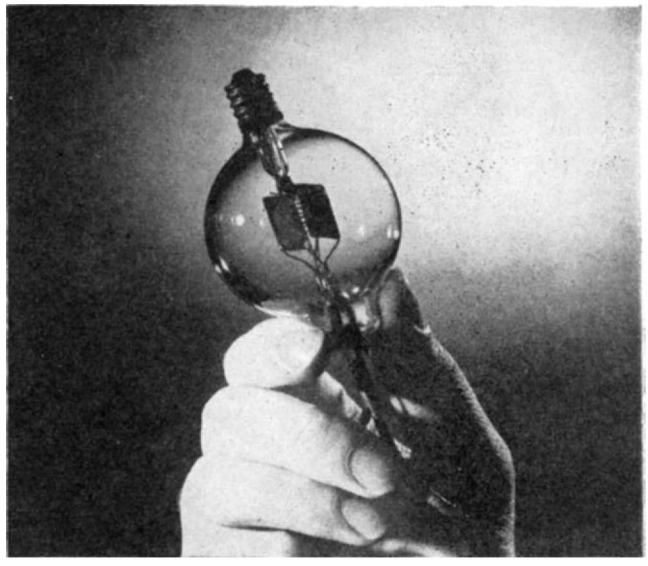
In electronic heating, one of the most promising industrial developments, radio waves are passed through objects such as wood, metal, and even foods and cloth to generate heat for gluing, drying, case hardening. annealing, riveting, welding, melting of metals, deactivating enzymes, and sewing of special plastics fabrics. In the processing of laminated wooden propellors electronics sets the glue in minutes instead of hours required by the steam process. Large rubber wheels are cured in 18 minutes by the electronic process while steam requires five hours. In the textile industry, rayon cakes are being dried uniformly in a matter of minutes compared with hours required by standard heating methods.

Supersonics, the application of high-frequency sounds by means of electronic equipment, has important possibilities in chemistry, metallurgy, medicine, and other fields, such as separating water from crude oil by means of vibration. Supersonic precipitation of dust and smoke and the purification of water are promising. Certain bacteria can be destroyed by intense vibrations. Degassing of molten iron to prevent holes is another possibility, and studies are being made in aging whiskey and other alcoholic products by the high-intensity vibration treatment.

ORE SEPARATION —A new electronic ore separator developed by Westinghouse Research Laboratories has successfully refined ores of such metals as tin, iron, and gold. The operating principle is much like that of the Westinghouse Precipitron that has been used for many years to remove smoke, dust, and liquid particles from air. Most promising results have been attained with low-grade ore samples from a recently developed tin deposit in a southern state. By spraying electrical charges on this ore, which contained only one and one-half percent tin, the new Westinghouse device separated the metal from rock and sand, concentrating it into an ore containing approximately 70 percent tin—suitable for smelting.

The ore is ground to the fineness of sand, dried, and then poured into a trough at the top of the separator. The particles of sand, rock, and tin trickle onto a rotating metal drum, where they receive high-voltage electrical charges from a series of fine wires a short distance from the drum's surface. Since the tin particles are good conductors of electricity, the electrical charges seep through them and into the metal drum. The tin particles then lose their charges before the drum has made more than one half turn and fall off the drum. But the poorer conducting sand and rock particles retain their charges and cling to the drum until pulled off--during the second half revolution—by a series of opposite charged wires.

The electrostatic separator can sort mixtures of any two materials provided one component is a conductor of electricity and the other such a poor conductor that it is in effect an insulator. In addition to experiments with low-grade tin and other ores, the machine may be used to separate foreign materials from grains, separate stems from raisins, and purify many types of foods.



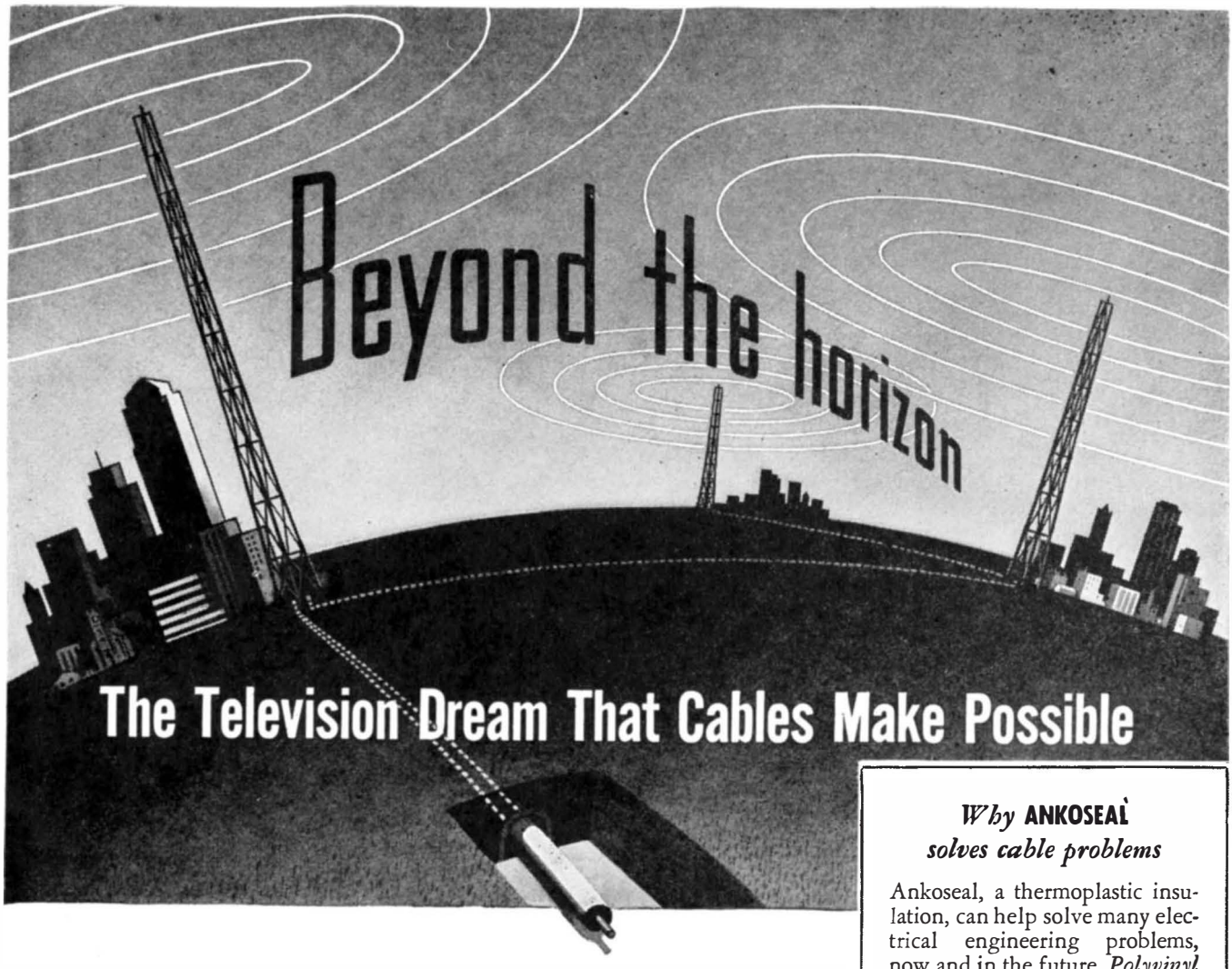
One of the first three-element vacuum tubes of the type that was invented by Dr. Lee de Forest in 1906

DAYS AHEAD—Today radio is no longer just crooners, baseball games, and music while you shave. It is mobile police protection at all hours, weather observer, automatic pilot, instant communication for fireboat and fire truck. It is operator of remote power stations, fire fighter, and cradle watcher. It has learned to serve as well as to amuse and educate. Tomorrow, when the thunder and pain and preoccupation of war have passed, radio — released from the manacles of static by frequency modulation (FM) and stripped of its blinders by television—will bring you the clear high note of the violin, the timber of the voice, and perhaps even the color of the umpire's tie. Electronics has in store for millions of homes of the future a radio performance that as yet has not been a part of their experience.

Of electronics' part in the war only a little has been revealed, but much will soon be written. While war with one hand withholds and obstructs peaceful scientific progress, with the other it actually pushes forward industrial research and application.

Under the lash of necessity, developments which might have taken years are compressed into months. The world will reap these fruits of war, and they will not be bitter. In the words of Prime Minister Winston Churchill: "We may be astonished at the progress in efficiency we shall suddenly find displayed . . . The ceaseless improvements in wireless and the wonders of radio-locators applied to the arts of peace will employ the radio industry . . . . With the modern methods of locomotion and the modern amusements of the cinema and wireless, to which will soon be added television, life in the country and on the land ought to compete in attractiveness with life in the great cities."

Before the invention of electronic tubes, electrical engineering was largely a science of wires and circuits. We were concerned with the jars and bottles and pipes in which electricity was stored, through which it was distributed. Now, with the electron tube, the engineer can command electrons so that they will do his bidding. For the first time he has command of electricity itself—not just of its manifestations. All that has gone before, important as it has been to our lives and fortunes, may well be only a preparation for a new and greater adventure in living.



TELEVISION—sign and symbol of the age to come—is one of the wonders that specially designed cable transmission makes practical. For the quality and fidelity of the transmitted image depend largely on how well the cables are engineered and manufactured, from tiny cables in the broadcasting mechanism itself to the great coaxial cables linking city with city, making possible the television networks of the future.

Thus the "wireless age" as it develops will actually need more wires—and more complicated cables—to achieve its realization! And in the solution of these problems, new and more complicated cables will be required.

Today, we will undertake to engineer and manufacture the radio and audio cable requirements of any government agency or private concern in war work. Moreover, we look forward to solving many of the most difficult cable tasks in peacetime—as we have in wartime. The same laboratories, the same Yankee ingenuity that have helped to whip many of the difficulties involved in the communications requirements of our Army and Navy are prepared to function for industry—whatever the problems of today and tomorrow.

Why ANKOSEAL *solves cable problems*

Ankoseal, a thermoplastic insulation, can help solve many electrical engineering problems, now and in the future. *Polyvinyl* Ankoseal possesses notable flame-retarding and oil resisting characteristics; is highly resistant to acids, alkalies, sunlight, moisture, and most solvents. Polyethylene Ankoseal is outstanding for its low dielectric loss in high-frequency transmission. Both have many uses, particularly in the radio and audio fields. Ankoseal cables are the result of extensive laboratory research at Ansonia—the same laboratories apply engineering technique in the solution of cable problems of all types.

THE ANSONIA ELECTRICAL COMPANY

Specializing in "Ankoseal" a Thermoplastic Insulation

ANSONIA • CONNECTICUT

A Wholly-Owned Subsidiary of

NOMA ELECTRIC CORPORATION

GENERAL OFFICES • NEW YORK, N. Y.

—In peacetime makers of the famous Noma Lights—the greatest name in decorative lighting. Now, manufacturers of fixed mica dielectric capacitors and other radio, radar and electronic equipment.

It Pays To Listen

Wire-Recording Equipment and Other Electronic Instruments are Giving New Ears to Factory Men. New Accuracies in Machine and Process Industries, Made Possible by Studying and Comparing Noises, Are Speeding Production, Improving Quality, and Cutting Costs

ONE of the latest tricks in industry is to install a microphone beside a large press which is just being set up. The microphone is connected to an instrument which records on a moving wire every noise the press makes when in operation.

The reason for all this is as old as the world of machinery and as simple as the whetting of a scythe. There is a characteristic noise peculiar to each machine which is working at its best. Tiny differences in machine and die settings will make sounds which betray them. Let those differences go undetected and the dies may fail many hours or even days before they would if perfectly set up. And die failures mean days of down time for the press while new or spare dies are installed—the wait is longer if there is only one set of dies which must be repaired before setting up the machine again.

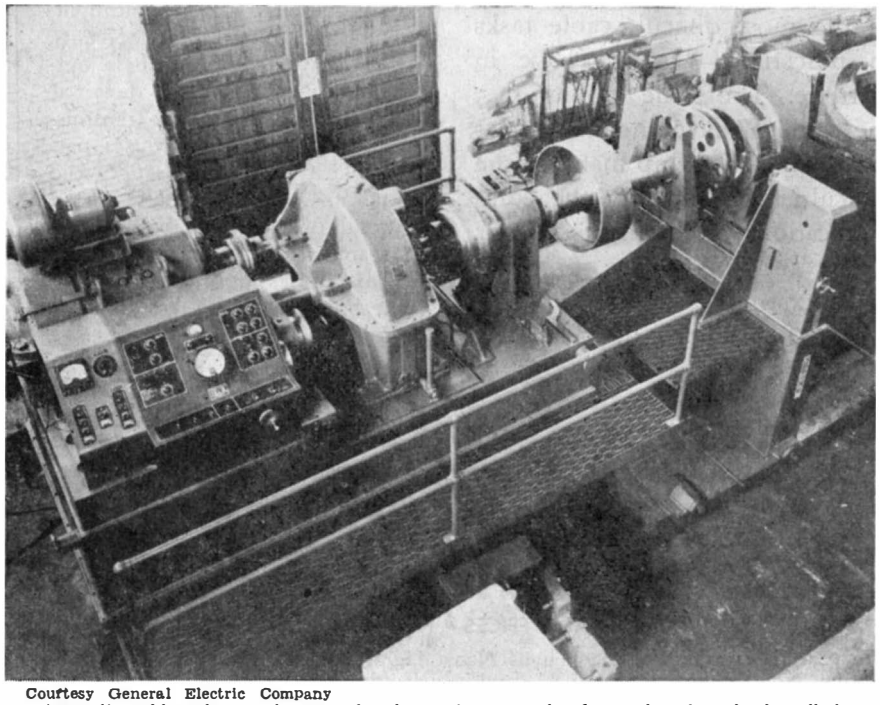
Once the machine has recorded its present noises on the wire, that wire is taken to a quiet room and played back through a standard radio amplifier and loudspeaker. Recorded on another portion of the same wire is the noise which the machine made on the set-up which resulted in the longest die life. The two are compared and the new set-up is corrected until the machine makes very nearly the same noise as it did with its most successful set-up.

Side by side with this noise inspection goes the usual microscopic inspection of the surfaces of the finished steel parts made on the press. The metallurgical laboratory still checks up the effects of the drawing operation on the grain structure of the steel parts. The comparison of the noises made by the press is just one more refinement of a highly exact setting-up process. The whole process results in longer lives for dies, higher overall operating rate of the press, more work done per operating month, better surface finishes on more accurate finished parts.

Sooner or later, of course, a more successful set-up than the "best known" one will be obtained. Then the standard set-up noises will be wiped off the wire and the new standard substituted. The whole noise-recording process is magnetic and the wire is not cut or marred by it. Hence the same wire can be wiped off magnetically and used for new recordings thousands of times.

The wire recording and repeating device is an electronic instrument. It is one of the means of giving his ears back to the factory supervisor; a process in which many instruments must serve.

The old-fashioned factory man had little need for such instruments. All around him milling machines moaned, shapers grunted, electric motors whined, heavily laden rough-toothed gears roared, belts squealed when being shifted, tumbling barrels rattled, saws sang, presses pounded. And to him every noise had a definite note, a definite meaning which could be interpreted. Although he might seem a little deaf when conversing in a quiet room, once he entered his factory he became a Stokowski and the machines were his symphony. At the slightest sour note he made corrections.



Courtesy General Electric Company

An adjustable-voltage drive with electronic control of acceleration is installed on this large dynamic balancing machine. The control panel may be seen on the left

CHARACTERISTIC SILENCES — Quietness entered factories slowly. The first of it came from the higher accuracies of high-speed machinery. A high RPM centrifugal pump cannot be allowed to make the pound-

Magnetic wire recorders, first brought into wide use for military needs, are finding many industrial applications

ing noises of the much larger but slower reciprocating ones; it soon would pound itself to pieces if it had any parts loose or ill-fitting enough to produce such noises. Ball bearings seldom can keep their high accuracies on poorly balanced, noisy equipment; motors which whine are likely to wear out quickly under heavy loads at high speeds; any machine tool which moans or grunts is wearing out its tools and bearings too fast as well as leaving chatter patterns on the finished work; gears that roar cannot carry modern high-speed heavy loads within the small spaces now alloted to gearing. Modern machines, instead of having characteristic noises, have characteristic silences.

Guarding and shielding brought more silence. Modern high-speed parts cannot be left unshielded. They are too dangerous, their lubricants will be thrown too fast and far, their delicate accuracies will be damaged by dirt unless they are enclosed.

The first guards actually increased the factory noises; they acted like drums. But modern guards have stopped all that; they stop noises and dampen vibrations.

Silence for its own sake came later. Managements noticed that heavy, noisy, slow-acting machines slowed down the working paces of men. The operators kept time to those machines as if marching to music. Other managements found that a prolonged noise also slowed down the men and promoted accidents.

Vibration absorbing pads, some of them four feet thick, were put beneath heavy presses. They reduced repair bills and increased the quality of the work as well as reduced the noise for the sake of nearby personnel. Floors, walls, and ceilings were made noise absorbent. Noisy machines and departments were enclosed. Soon, many a busy factory became as quiet as a hospital.

But while all this was going on the factory man began to miss his tell-tale noises. He had to have them back, and in sharper, more definitely identifiable forms.

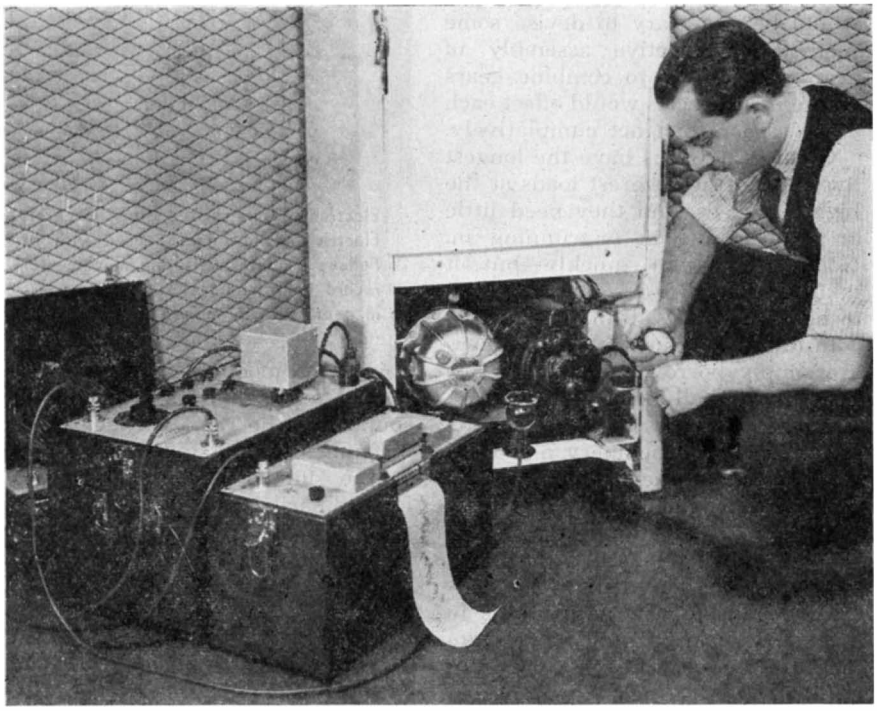
INSTRUMENTS THE ANSWER—The production manager of a plastics factory had been accustomed to listening to his old-style steam traps every day. If the traps were working then he was getting wet steam but no free water at his moulding dies. If they were not working, it meant production troubles plus rusting of pipes and of die interiors.

New and more efficient traps did not make any noises that he could hear with his naked ear. A physician's stethoscope helped some, but brought wisecracking comments from the employees. The final answer was a portable microphone which amplified the noises so highly that any of his well-trained assistants can use it. His steam traps used to be one of his daily worries; now he has dismissed them from his mind.

The highly skilled tool maker who grinds small broaches to accuracies of one hundred thousandths of an inch, complained that vibrations in the tool room were spoiling his work.

His machine was moved to a vibration-free room. Still his troubles continued.

Then it was found that what he needed was not less noise but more of more identifiable noise. His vibration-free room was completely sound proofed so there would be no reverberations from the floor, walls, or ceiling. Then an electrical noise magnifying instrument was attached to the tail stock of the grinding lathe. Now the noise of his machine tells him when he is likely to run into trouble even before such trouble is shown up by his highest accuracy dial gages and tool maker's microscope.



Courtesy Western Electric Company

An electronic "stethoscope" being used to test refrigerator units. This device produces a permanent charted record of the sound level at each frequency passed

Super-accurate gearing needed noise amplification in the inspection room. Gear teeth were being finished to the highest obtainable accuracies and with surfaces smooth within eight millionths of an inch—some had been made smooth within one millionth of an inch but it was found that lubrication would not work correctly on such smooth surfaces. Even with all this accuracy it was found that some trains of gears would fail for lack of accuracy while others would not.

With instruments which depend upon light waves and upon contact doing all they could to find inaccuracies which caused the failures, some other testing means had to be tried.

A noise testing machine was devised. Characteristic noises of the running trains of gears quickly isolated the edge squeal which indicated that the leading edges of teeth were giving trouble, the knocks from the impacts of irregular teeth, the rattles from variations of helix

angles, the whines and squeals and other noises of strut or wedging action and of tip interference, the rattles from inaccurate bearings. But strangely enough it was found that many noises came from teeth which were as accurate as human means could make them but whose inaccuracies nevertheless combined with each other to produce bad running conditions. Consequently it was decided that, in spite of highest accuracies in cutting the gears, it would be necessary to devise some method of selective assembly of gear trains so as to combine gears whose inaccuracies would offset each other rather than act cumulatively.

Quiet gear trains have the longest lives under the severest loads at the highest speeds, and they need little or no breaking in or running in. Noisy trains fail quickly—but it takes a specially designed machine to hear any noise at all.

In this technique the gear makers are simply borrowing an old practice of the ball bearings industry. After ball bearings have been made as accurate as machinery and testing can make them, noise testing will find defective ones. Take a noisy bearing apart, and only very rarely can instruments measure the inaccuracy which caused the noise. Reassemble these parts with others to make new bearings and the minute inaccuracies—measurable only in millionths of an inch if measurable at all—may so balance each other that the bearings will be quiet. And yet the noisy bearings on the testing machine sounded like a flat wheeled freight train going at high speed over a loose trestle while the quiet bearings made only slight swishing sounds.

THEY KNOW BY NOISE—Quite different from these testings for highest accuracies are some of the noise detection methods in use in process industries. One fermentation vat, for example, used to be open at the top and its contents were allowed to assume whatever temperature the process produced. In those days it was easy for skilled men to listen to the noises made by bubbles of gas rising to the surface and to judge by this whether or not the vat contents should be stirred.

Now the vat is totally enclosed, and its temperature is carefully regulated to control the rate of fermentation. Analysis of the gasses given off can tell a great deal about the progress of the fermentation. But noise is still the final test.

Differing from the old practice of having a trained man climb to the top of the vat and listen attentively for delicate nuances in the noises, the modern electrical microphones make the rising gas bubbles sound like the roar of Niagara—the instrument brings out enough noise so the state of the process is easy for ordinarily trained ears to detect.

Electronically operated, this General Electric profile gage is used with a Fellows involute measuring machine to record on a paper chart inaccuracies in gear teeth as minute as .0001 inch

Judging the exact time that materials should remain in processing barrels used to be a matter of instinct and guesswork. Now instruments magnify the noises made by the cascading materials and tell the whole story. Noise detectors will warn of the presence of slightly wet steam in turbines intended only for dry steam—the wet steam erodes the blading if not corrected.

Strangely enough, noise detectors also are used to tell when there is too much quiet. In a battery of inter-connected Diesel engines, for example, one engine can cut out but continue to revolve and to run fuel through its cylinders until its lowered temperature tells the story. But a noise-detecting instrument in the room will instantly react to the changed level in the total volume of sound, and the engineer can find out which engine is wrong long before its temperature drops appreciably.

These contributions of electronics to industry are certain to increase in value. There can be no point in reducing plant lighting; therefore the engineer will always have his eyes. And as the noise level is reduced, electrical instruments give him back his ears.

BUCKLED PLATES

Prevented by Applying More Heat for Shorter Time

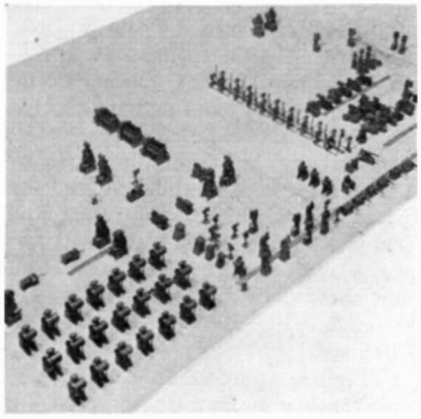
A RAPIDLY advancing technique in arc welding is to use larger electrodes on steel plates and other thin sections and thus apply more total welding heat but apply it to any one section for a shorter length of time.

The purpose is to prevent buckling of the thin sections. And the technique contradicts a time-honored theory that the greater the total heat the greater the buckling. Evidently, buckling is promoted more by giving heat time to build up so that there are large bodies of hot and expanded metal which later must cool and shrink than by applying more heat in a shorter time and thus heating smaller areas of metal to temperatures high enough to cause trouble.

PLANT LAYOUTS

Easily Made With Scale Models

THE CLASSIC method for making plant layouts is to draw scale diagrams of floor spaces, make cardboard pieces representing the machines and equipment reduced to the same scale as the floor plan, and, after moving the pieces about on the diagram until a satisfactory arrangement is found, reduce the final layout to a blue print.



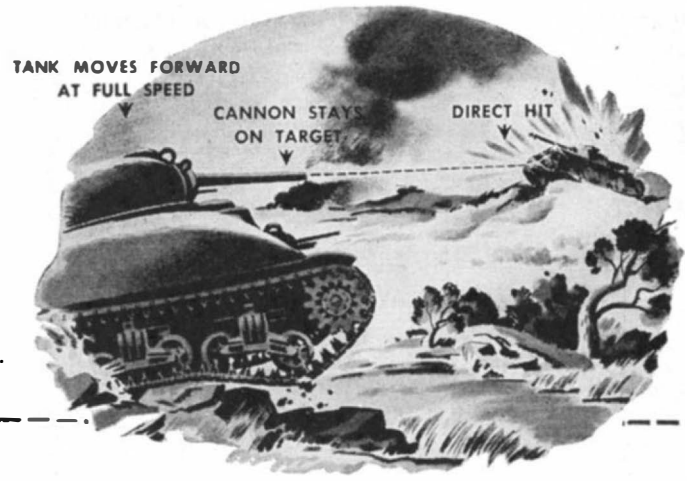
A Westinghouse model plant layout

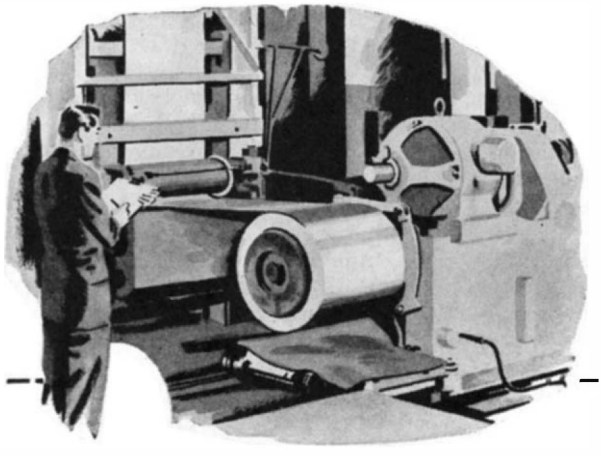
A newer method calls for making scale models of the machines, the conveyors, and other equipment. These provide a much better mental picture of how the new plant will look and how the production line will be coördinated. And, once properly placed, the models can be photographed to give the installation men clearer conceptions of what is wanted than can be had by reading blue prints.

With plant changes as frequent as they are today, the models also serve to show how rearrangements will look, and how new products can best be accommodated on present production lines.

In an Army tank a GUNNER fires with deadly accuracy – while charging across rough terrain – because of a gun stabilizer, officially recognized as one *outstanding advantage* of our tanks over those of the enemy.

. . . the name on the GUN STABILIZER is Westinghouse.





In a steel mill an ENGINEER uses an induction heater to fuse a mirror-like surface on dull electrolytic tin plate – helping to conserve *two-thirds* of our war-scarce tin supply.

. . . the name on the INDUCTION HEATER is Westinghouse.

In a laboratory a SCIENTIST uses a micro-balance to weigh a *single layer of oxygen atoms,* 1/50,000,000th ounce, to determine the corrosion resistance of special alloys at high temperatures.

. . . the name on the MICRO-BALANCE is Westinghouse.

In a bomber a BOMBARDIER "pin-points" his target with an American bombsight – controlled by a gyroscope which is driven by an electric motor, balanced to *1/10,000th ounce.*

. . . the name on the ELECTRIC MOTOR is Westinghouse.

Westinghouse

PLANTS IN 25 CITIES OFFICES EVERYWHERE

TODAY – Westinghouse is producing vital war equipment and weapons, many of which must remain secret until after final Victory.

TOMORROW – These wartime developments will be turned to peaceful uses – products for industry and the home, backed by Westinghouse research, engineering, and precision manufacture.

Tune in: JOHN CHARLES THOMAS–Sunday 2:30 pm, EWT, NBC • TED MALONE–Mon. thru Fri., 11:45 am, EWT, Blue Network

Better Plastics Heating

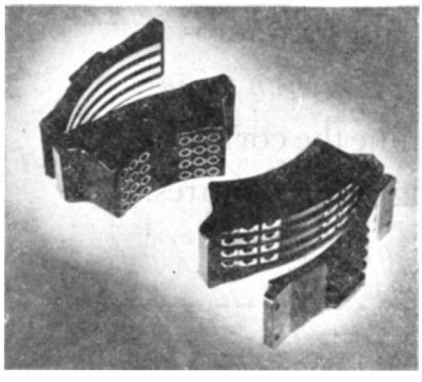
In Wood Fabrication and in Preparing Plastics Materials for Molding, High Frequency Heating is Well into the Development Stage. The Success that Has Been Attained Bids Fair to Influence Favorably The Rapid Production of Even Large and Complicated Plastics Parts

HIGH-FREQUENCY heating is now being used to an ever increasing extent as a means of preheating plastics molding materials and of accelerating curing of synthetic resins used as adhesives in wood fabrication. For this latter purpose, high-frequency power has proved to be remarkably useful. For example, it is responsible for the record of one company in turning out cargo-carrying glider parts at a continuously increasing rate with an ever decreasing cost to the Government. In this instance the electronic device was originally intended to facilitate gluing of laminated parts for grand pianos. However, when all piano manufacture ceased by order of the War Production Board in May 1942, only the fashioning of various new jigs and fixtures was necessary to convert the high-frequency unit to work on resin-bonded aircraft parts.

Experience in the wood fabricating field has indicated that the location and arrangement of the electrodes has a vital effect on the ability of the high-frequency machine to transmit the power through the system of electrodes and on the likelihood of the work absorbing this power uniformly and utilizing it as heat. The three established methods of introducing high-frequency heat to a glue line or to a mass of material are known as perpendicular, parallel, and stray field heating.

Perpendicular heating is referred to when the glue lines or planes are perpendicular to the electrostatic field and parallel to the electrodes. The gluing of veneers in the manufacture of plywood or the gluing of laminations to form curved sections such as wing bows are considered as being treated by perpendicular heating. The preheating of plastics materials before molding, to be considered in more detail later on, is also done by perpendicular heating.

Parallel heating requires that the plane of the glue line be parallel to the electrostatic field and perpendicular to the electrodes. This method is considerably more efficient than perpendicular heating since the power is absorbed almost entirely by the glue line rather than by the wood itself. For example, where wing spars are being made of several laminations that are a half-inch or more in thickness, the power required to set the glue in perpendicular heating would be beyond the range of the ordinary machine of 15 kilowatts or less. However, if the electrodes are located so that only the glue lines are treated—that is, by parallel heating—the power and time requirements are reduced enormously.



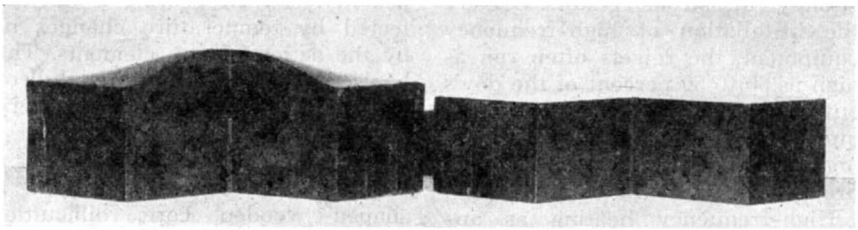
Use of a five-kilowatt high-frequency oscillator to preheat preforms not only increased production but lowered warpage in molding this phenolic part used in an electrical assembly for feathering propellers

Stray field heating offers the greatest possibilities but is the most complicated of the three methods. In this case advantage is taken of the fact that the electrostatic field set up by two adjacent conductors or electrodes, usually in the form of tubing or rod, does not travel on a straight line between these conductors. The field spreads out or widens as it leaves one electrode and finally converges as it reaches the other. Thus it is possible to reach glue lines and surfaces that are not directly in line with the electrodes but are a definite distance above or below them.

NOT A CURE-ALL—In the field of wood fabrication as well as in that of preheating molding materials, high frequency has certain shortcomings. It is not a cure-all. Where the section to be heated is very thin, a steam plate or electrical resistance grid usually is more desirable. High frequency should be used in objects where the physical dimensions do not allow for uniform distribution of ordinary heat. Conventional heating methods are definitely not satisfactory where the depth of heat penetration is more than ⅜ or ½ inch.

The most important use of the high-frequency machine in the wood-working industry is to speed production. And this it has done by drastically reducing the time required to cure a glue joint—cutting it from four to six hours to a matter of seconds or minutes.

Preheating of molding materials prior to the pressing operation is not new. Through such heating it has been possible to improve the flow of material to the mold, accelerate the closing of the mold and the curing of the piece, and reduce closing pressures. However, although many advantages have been obtained by this method, the fact remains that molding materials, being insulators, resist heat absorption. Because of this, a preform which is heated without benefit of high frequency is much hotter at the outside surface than it is at the core.



Courtesy Bakelite Corporation

At left is a molded block of woodflour-filled phenolic material which was cured in one hour at 320 degrees, Fahrenheit, at a pressure of 2100 pounds per square inch. Made of the same material and molded at the same heat and pressure, the block at the right, six inches by six inches by two inches, was cured heatronically in five minutes

In fact, the material may be relatively cool at its core when the outer surface has become crusted.

PREHEATING PROCESSES — One common means for preheating is the double steam plate in which a layer of preforms is placed between the upper and lower plate. Another method employs an oven with shelf arrangement. With this setup, either preforms on trays or bulk powder in pans can be heated. These methods have been used for years and, no doubt, always will be used. But in principle they are resisted by the materials themselves.

In contrast, the development of radio frequency for preheating has, for the first time, given the molding industry a method whereby a charge of material can be heated nearly uniform throughout its mass in a very small fraction of the time previously consumed. Of particular importance is the fact that when a preform is heated in this manner the heat is generated uniformly throughout the material, irrespective of size. And the rate at which this heat is developed is directly proportional to the power input. This means that the heat conductivity of molding materials, precluding size and weight as limiting factors, no longer has to be considered. Thus, theoretically, any quantity or weight of thermosetting molding material can be heated to molding temperature.

With minor modifications, the heatronic process is applicable to the molding of a variety of plastic materials. Thus, thermoplastics may be molded with considerable advantage by compression. Brake-lining materials have also been heated and molded satisfactorily from preforms and powder. If certain precautions are taken—especially as to rate of heating—materials which are partially conducting and materials containing conducting particles can be heated in this manner and molded. Colored and mottled materials as well as black and brown phenolic compounds will mold satisfactorily when heated by high frequency. Experience has indicated that, generally speaking, the slower curing materials are preferable for thick sections and for moldings requiring exceptional flow. Although urea and melamine are more critical in this respect than phenolics, they have been molded by the heatronic process with considerable success.

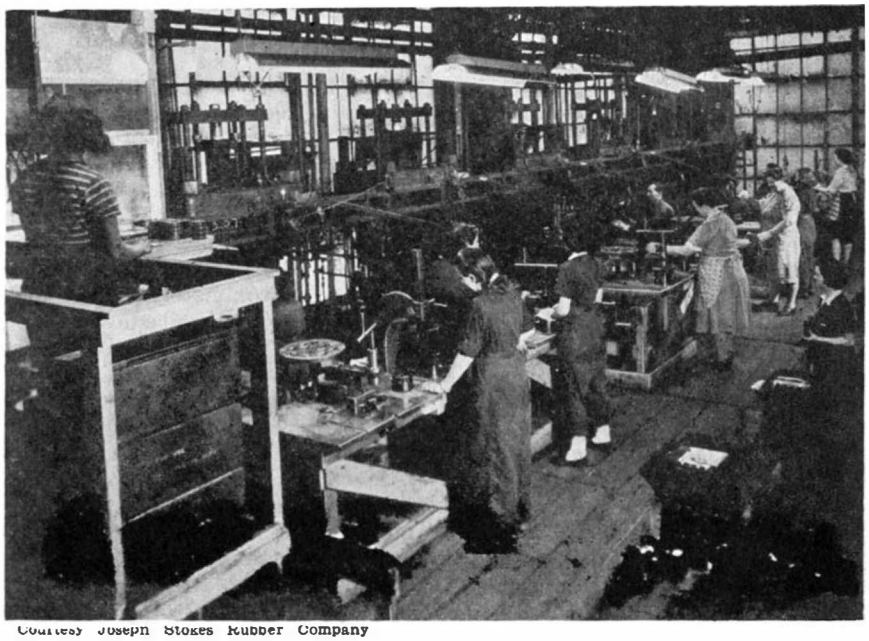
METHODS OF APPLICATION — There are a number of methods of adapting this heating technique to present-day molding. A simple yet effective system consists in heating the preformed material to molding temperature in the electrostatic field which is set up outside the molding press. After heating, the material is quickly transferred to the mold or transfer pot, and the press is closed rapidly so that the desired flow is obtained prior to hardening. This transfer of the preheated material may be manual or automatic.

Such an arrangement can be varied in a number of ways. In transfer molding, the electrostatic field may be created over the mold and the heated material allowed to drop into the mold or be forced in by the mold plungers. In the case of a horizontal ram in the transfer mold the electrostatic heating plates may be mounted between the ram and the mold.. Here use would be made of the ram to force the heated material into the mold.

The size of the high-frequency heating equipment depends upon the size of the job to be done. In the past year new designs have been engineered to meet efficiently the specific needs of the plastics industry, extreme simplicity and ease of operation being the keynotes. Keeping in mind the fact that preforms differ markedly in size and shape, provision has been made in some of these units for changes in the size of the electrodes. And safety devices have been featured throughout.

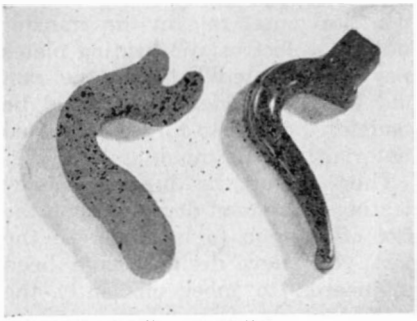
The advantages of preheating are numerous. Briefly they may be summarized as follows: precise control of preheating; shortening of the preheating time; much lower molding pressures; less mold distortion and damage; simpler molding cycles; fewer contraptions at the press; simplified material loading; less material handling; slightly less loading weight; lower plasticity required; less warpage experienced; no "weld" lines; minimized internal stress in the molded piece; uniform density of the part; thoroughly cured molded piece; generally improved properties; more pieces per press and per man-hour; much faster cure.

"IMPOSSIBLE" JOBS—Just what these advantages mean is perhaps best explained by citing a few of the seemingly impossible jobs that were successfully molded through the use of high-frequency



Courtesy Joseph Stokes Rubber Company

To obtain maximum results from a high-frequency oscillator, one company has engineered a conveyor system for the speedy transfer of preheated forms to the presses



Courtesy Bakelite Corporation

Made of phenolic material, the preform at left was electronically heated to 300 degrees, Fahrenheit, in 30 seconds and molded in 45 seconds at 320 degrees to form the handle for a coffee maker pictured on the right

heat. There is, for example, the phenolic head of a chemical pot-feed device in a water purifying unit. In producing this head part—a fairly large part weighing approximately 1 pound 6¾ ounces and measuring about 5 by 5 by 2 inches—the molder wanted to make sure that there would be no leakage between canals molded in the head and that no cracking would take place in the part under extreme temperature changes. Before the molder adopted high-frequency heating, at no time was he able to produce a head that did not have porous internal sections which resulted in leakage between the canals. However, the uniform preheating of the material by high-frequency produced complete uniformity of the molded part with no indication of any porosity or internal strains.

An even more difficult molding problem satisfactorily solved through the use of high-frequency heating was an aircraft engine ignition distributor head molded from asbestos-filled melamine compound. The difficulty lay in a combination of circumstances: The low thermal conductivity of the compound, the size of the part, the close nesting of a large number of pins, and the complex arrangement of 17 inserts. To secure proper flow from the transfer chamber into every section of the mold, the 2¼-pound preformed plastics was preheated to 250 degrees, Fahrenheit, before it was placed in the loading well. Only by a rapid, uniform heat could such a mass be heated to the center without overheating the surface at the same time. If the core were underheated, the material could not be made to flow into the cavity without the use of such great pressures that pins would be broken or bent and inserts sheared off or moved out of position. If the surface of the preforms were overheated in an attempt to soften the core, the compound would begin to set—with equally disastrous results. Before the installation of high-frequency equipment, the rejects often ran as high as 30 to 50 percent of the day's output. However, once high-frequency was adopted for the heating of the preforms, this percentage dropped below 5 percent.

High-frequency heating as applied to the plastics industry is well into the development stage; the work that has thus far been accomplished with its help in this field is indicative of how research and development can influence and change the course of business.

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VENTILATING DUCTS

Made of Steel Springs and Plastics Treated Fabric

FRESH clean air is assured construction men working in such enclosed spaces as the holds of ships by portable "Ventube" flexible ventilating ducts developed by E. I. du Pont de Nemours and Company, Inc. Designed for either blower or exhaust systems, the unit consists of a tempered steel helical spring inside a tube of specially selected fabric which has been impregnated and coated with a high-grade abrasion-resistant plastics compound that is water-resistant and impermeable to air. When bent to an angle of 180 degrees, the new Ventube will exhaust more air than the old-style tubing, and, in addition, it weighs only half as much as an equivalent length and diameter of the earlier types.

BETTER HEELS

Result from Improved Plastics Injection Method

AS A RESULT of a new development in injection molding, the wooden heel cores of women's shoes can now automatically be given an evenly distributed coating of cellulose acetate approximately 1/16 inch thick. The new plastics-covered heels, which are said to have wearing qualities far exceeding those of any other shoe, will not scratch or scuff, nor will the coating wear off, split, or peel. The latter characteristic can be attributed to the fact that the plastics is slightly impregnated into the wood under the pressure of injection. There is no seam, and the process, which was developed by Pereles Brothers, can be used for any size, shape, or style.

According to the results of repeated tests, the coating is not affected by temperature changes or by the action of any elements. The heels can be made in either dull or glossy finish in practically every color.

In previous attempts to mold a plastics shell or coating around a shaped wooden core, difficulties were encountered, due mainly to the high pressure employed in the injection process. With the wooden forms supported in the mold by

Plastics covered wooden heels

pins extending into opposed ends of the core, the pressure of the molten plastics material entering the mold by the usual direct feeding methods shifts the core on the supporting pins. This movement often results in unequal application of the coating material to the core.

To overcome this difficulty, a new type of gating was adopted. It is essentially a modification of a ring gate. The spaced indirect feeding arrangement made possible by this gating provides for simultaneous and uniform flow of the cellulose acetate, under similar pressure conditions, all about the core. Consequently, there is no tendency of the core to be shifted, and the coating is uniform throughout.

COLORED CONNECTORS

Insure Safety in Electrical Installations

FOR EASE of installation and to simplify replacement work and trouble-shooting, H. B. Sherman Manufacturing Company has adopted red plastics fixture connectors for use on current-carrying wires and white plastics connectors for grounded wires. This color code also lessens the danger of accidents. Detroit Macoid Company molds the fixtures from Vinylite because of its non-flammability, high tensile strength, moisture resistance, and electrical resistivity.

DUREZ

PHENOLIC RESINS

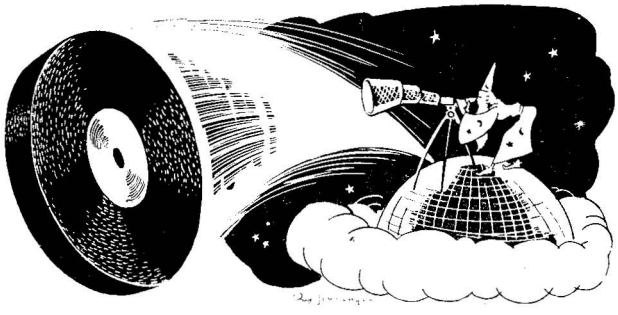
- MOLDING COMPOUNDS
- INDUSTRIAL RESINS
- OIL SOLUBLE RESINS

MOLDING COMPOUNDS

THRIVING ON A DIET OF "LIGHTNING BOLTS"

The rigid requirements for arc resistance, dielectric strength, and heat resistance which the modern distributor cap must pass call for a plastic compound of unusual versatility. Naturally, this means that the automotive distributor cap manufacturer looks to the phenolics because these are the most versatile of all plastics . . . and when he looks to the phenolics he looks to Durez—specialists in this field for the past quarter century. In addition to the electrical and heat resistant properties which a plastic compound for a distributor cap must have, the Durez phenolic molding compound selected for this job possesses such characteristics as good moldability, moisture resistance, and low shrinkage. You will find the versatility of the more than 300 Durez phenolic molding compounds is the natural starting point for selecting a plastic material that fits your job.

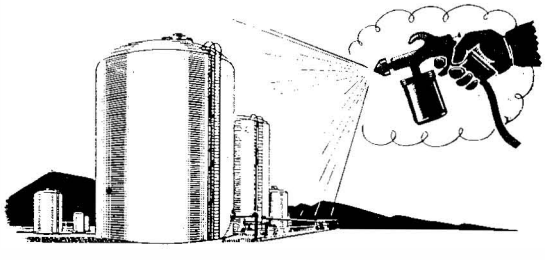
INDUSTRIAL RESINS



LOOKS LIKE A LONG HARD GRIND AHEAD

Grinding wheels bonded with Durez resin possess the durability, strength, and accurate grinding power so necessary for efficient production. Relatively simple to produce, Durez-resin-bonded grinding wheels are typical of the many—almost limitless—applications which Durez bonding resins have made available to the progressive manufacturer with an eye on post-victory markets.

OIL SOLUBLE RESINS



THE NEXT BEST THING TO THE FOUNTAIN OF YOUTH

Durez resins impart to aluminum paints the brilliance, gloss, and durability that make them amazing life prolongers for such items as petroleum storage tanks. A myriad of wartime developed (and proved) applications for Durez resins in the protective coatings field opens new horizons for the alert manufacturer.

● Versatility is a much misused word and, especially when referring to the properties of plastics, deserves elaboration. When we say that Durez phenolic resins and molding compounds are versatile, we mean that they possess a wide range of highly desirable properties such as highest dimensional stability under all types of climatic conditions, chemical resistance, impact strength, heat resistance, diversity of finishes, dielectric strength, and moisture resistance. But there is even more to it than this—for when you add to the product versatility of Durez plastics the many new molding methods and processes developed by your custom molder and the tremendous advances made with Durez resins in the impregnating, bonding, and coating field, you can readily understand the tremendous scope that is now available to the imaginative design engineer. The benefits which the wide experience of Durez technicians and the wealth of data available in our files can offer are available at all times towards the successful solution of any plastic material problem which you may have. Durez Plastics & Chemicals, Inc., 527 Walck Road, North Tonawanda, N. Y.

PLASTICS THAT FIT THE JOB

Control In The Air

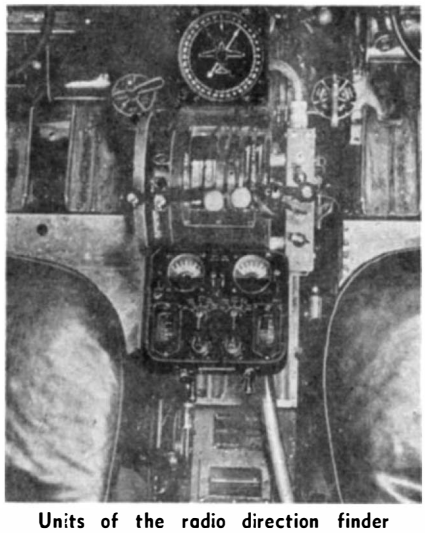
Electronics Has Brought to Aviation a Versatile Means of Controlling Many of the Airplane's Essential Mechanical Components. Increased Engine Efficiency, Reduced Pilot Fatigue, and Greater Safety are Some of the Worthwhile Results that Have so Far Been Obtained

THE SCIENCE of electronics is highly complex, yet the principles underlying most aircraft electronic installations are relatively simple. The heart of every installation is the amplifier circuit which, with electronic tubes, boosts a very small amount of electric power to usable proportions.

Of the many methods of creating the initial impulses in an electronic control system, it will be sufficient to say that they can be created by moving a coil in a magnetic field, or by changing the intensity of a magnetic field near a coil; by changing the capacity of a condenser; by varying resistance in one branch of an electric circuit; by photoelectric action; by employing the varying electrical resistance of materials at different temperatures; by actually breaking or closing an electric circuit; and so on.

REGULATING SUPERCHARGERS — One of the most important adjuncts to the military and commercial airplane is the turbo supercharger, indispensable to flight at great altitudes because it raises the rarified air to a pressure at the carburetor inlet almost equal to that at sea level. When the pilot has to control the action of the supercharger, he adds greatly to his already complex duties; hence such an automatic electronic control as developed by the Minneapolis-Honeywell Regulator Company is a valuable addition to aircraft instrumentation.

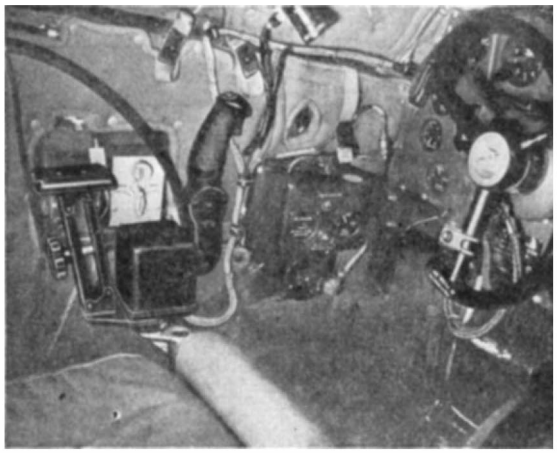
In a typical airplane engine equipped with a turbo supercharger, hot exhaust gases from the engine pass through the inlet and enter the nozzle box which surrounds the turbine wheel. Since it is the turbine wheel which drives the supercharger, and since it is the speed of the supercharger which largely regulates the pressure boost at the carburetor, the problem is to control the speed of the turbine wheel automatically. Basically, speed control is dependent on the waste gas. With the waste gate closed, all the gases impinge on the turbine and its speed is then at a maximum. As the waste gate is opened, more gases escape to the atmosphere, and the speed of the turbine decreases. Air is brought into the supercharger or turbo compressor inlet, and its pressure is increased by the impeller. Compressed air when heated lessens volumetric efficiency at the engine. To avoid this, the heated air is first led to an intercooler, where it is cooled by air brought in from a scoop, and then is passed on to the carburetor. An internal blower still further increases the air pressure before it passes to the engine manifolds.



Units of the radio direction finder as seen from a position just behind the seats of the pilot and co-pilot

ELECTRONICS DOES IT—Control requirements of the supercharger are many and severe. It should be completely automatic. Fluctuations in engine power must be met quickly and accurately; control of power must be by boost pressure rather than by throttle. For safety's sake, the turbine must not exceed a certain speed, or manifold pressure a certain value; low temperature must not be a bar to efficient operation. The combined efforts of the mechanical engineer and the electronic specialist have met these requirements completely.

The sensitive unit of the supercharger control system is the Pressuretrol which measures electrically the pressure of air supplied to the carburetor. It consists of two operating bellows and a reference bellows. Together they move a potentiometer contact by means of a sector arm and a pinion gear. Then



The electronic control stick, which makes close formation flying easier for the pilot by reducing fatigue, has a comfortable pistol grip and adjustable arm rest at left

there is a waste gate motor which is a two-phase reversible electric motor operating a balancing potentiometer within its own case. Another unit is the turbo governor, driven by a flexible shaft from the supercharger. One part of the turbo governor prevents overspeeding; the other part anticipates overshooting of the manifold pressure.

All these units are connected in the main junction box to a complex electric bridge circuit. When the units produce conflicting electric effects on the bridge circuit, an unbalance is signalled, amplified by the electronic amplifier, and the waste gate motor is set into operation.

In a plane equipped with an automatic supercharger regulator, the pilot selects engine speed by setting the propeller governor control on his dashboard, and opens the throttle wide. The internal blower gives a constant boost, so that if the turbo boost selector gives a constant pressure before the carburetor, a constant manifold pressure is bound to follow. Once set, the delicate electronic system keeps pressure constant and prevents overspeeding of the turbine. Because of electronic amplification, all signalling and "thinking" devices can be small and delicate, yet their final action powerful and rapid.

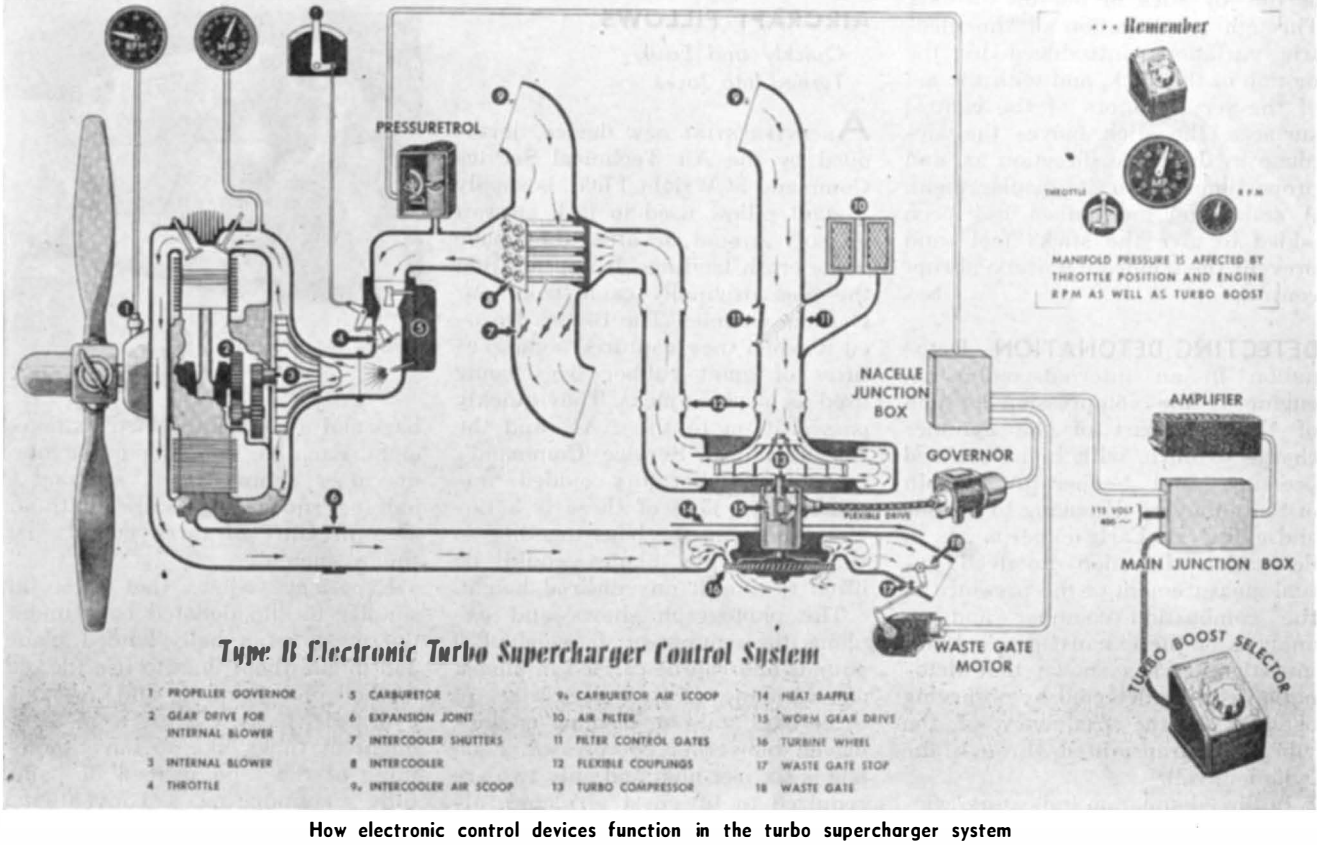
CABIN COMFORT—Control of the temperature of an airplane cabin is another extremely important phase of aerial flight which is being taken over by electronics. Post-war, equable cabin temperature will be maintained on our airliners, even though the airplane moves from one temperature to another in a matter of seconds, and sometimes these changes are as much as 50 degrees or more. The new Minneapolis-Honeywell "electronic cabin temperature control" is a package unit weighing slightly under eight pounds. It maintains the desired cabin temperature of 70 degrees, Fahrenheit, automatically in spite of extreme fluctuations outside.

The temperature control system includes an outside air compensator. This is a small coil of wire installed in the duct bringing the air into the cabin heaters. Temperature fluctuations change the electrical resistance of the wire. The change in resistance is slight, but even the smallest variation is amplified through electron tubes. Serving as the brains of the system, the tubes learn from the compensator coil whether the outside air is colder or warmer, and send electrical messages to a motor which opens or closes a mixing damper, proportioning the amounts of outside air mixed with heated air from the plane's cabin heating system.

THE AUTOPILOT—Electronic devices do not constitute a whole control system, but merely act the "liaison" part. This is well exemplified in the "electronic autopilot." The primary unit is not electronic nor even electrical in character. It is a gyroscope or a number of gyroscopes in a case fixed to the plane. The plane may dive, climb, or bank, but the gyro rotor remains fixed in space. In older systems, the difference in attitude between rotor and its case-operated ports or valves led compressed air or hydraulic pressure through piping to servo motors. The servo motors in turn operated the rudder, ailerons, or elevator.

In the electronic autopilot, the relative displacements of gyro and plane are picked up electronically and amplified into a force strong enough to actuate the control surface motors. It is claimed for the electronic autopilot that its action is practically instantaneous and refined; that the connecting electric wires are immune to extreme cold; and that no leakage of air or hydraulic fluid is to be feared. Another advantage is that the control surfaces are connected by many fine wires, making it more difficult for gunfire and flak to put the autopilot out of commission as compared with mechanical, pneumatic, or hydraulic systems. It is no longer a secret that the electronic autopilot is used on bombing aircraft such as the B-17's, B-24's, and B-29's to relieve pilot fatigue on long runs. It also enables the airplane to be flown from two or more stations. Pilot or navigator may be disabled, but another member of the crew can carry on.

It is now permissible to say that



How electronic control devices function in the turbo supercharger system

the electronic pilot has proved most useful in precision bombing. With the automatic correction it introduces, it is the bombardier who actually operates the plane on a bombing run. The result has been to reduce the vulnerability of our aircraft because the effectiveness of enemy anti-aircraft fire is directly related to the time consumed in the bombing run. Single aircraft have made approaches with runs of only eight seconds. The greatest contribution, of course, is improved accuracy of bombing.

ELECTRONIC JOY STICK—The "formation stick" is an original war-time electronic development. In early flights of American heavy bombers over enemy territory, attacks by enemy fighters compelled the use of tight formations, with planes flying almost wing-tip to wing-tip. In turbulent air, such precision flying called for great effort on the part of the pilots who often arrived over their target fatigued, just when precision bombing demanded their utmost alertness. Accordingly, Wright Field encouraged the development of a device which would take over all effort required in formation flying and substitute the servo motors of the autopilot for the muscles of the flyers.

As seen in the pilot's compartment of a bomber, the formation stick is a pistol-gripped lever about ten inches long, free to move in all directions in exactly the same manner as the joy stick of pursuit aircraft. Through amplification of the electric variations introduced by the motion of the stick, and with the aid of the servo motors of the control surfaces, the stick moves the airplane in the same direction as, and proportionately to, its displacement. A stabilizing mechanism has been added to give the stick "feel" and prevent the application of too abrupt control.

DETECTING DETONATION—Detonation in an internal-combustion engine is the compression-ignition of the last part of the cylinder charge to burn, with high localized pressures and temperatures. Both of these may be damaging to pistons and cylinders. Early experiments in detonation detection involved actual measurement of the pressure in the combustion chamber and an analysis of the exhaust gases. Later investigation has shown that detonation can be detected by observing changes in the frequency of the vibrations transmitted through the cylinder wall.

In the "detonation indicators," developed by the Sperry Gyroscope Company, a pick-up unit is attached to the cylinder wall and connected through an amplifier to a neon light indicator on the instrument board which flashes a warning when detonation conditions occur. No piercing of the cylinder is necessary to make an installation, and the equipment will serve all types of power-plant installation. Further, it is possible to discover immediately which cylinder is at fault by the operation of a selector switch.

DE-ICING—Among the many electronic devices developed by the Eclipse-Pioneer Division of the Bendix Aviation Company is one that improves the efficiency of the de-icing boots used on the wing edges of airplanes. The new control permits a more selective method of inflating and deflating the tubes along the wing edges so that ice broken loose by the pulsating rubber can be carried off by the slipstream.

Pressure and suction manifolds are located at the individual de-icer boot connections. The manifolds are operated by solenoid-actuated distribution valves, precisely and instantly controlled by an electronic timer. Originally there was a single recurring cycle of inflation and deflation fixed at approximately 40 seconds. Now an electronic device measures the thickness of the ice and permits the pilot to vary the frequency of the pulsations in relation to the thickness and type of ice being formed.

OTHER APPLICATIONS—Electronic flame detectors, in which photoelectric cell circuits are affected by the presence of flame or smoke, serve as quick-acting fire alarms. An engine temperature control furnishes voltage to the amplifier, so that temperature variations operate cowl flaps, admitting more or less cooling air as circumstances warrant. Remote actuation of airplane controls and accessories by electronic means has been greatly aided by the design of small but powerful electric motors of low inertia and with the ability to turn rapidly in either direction. The Sperry automatic direction finder makes every radio transmitter a possible source of guidance. The list of such appliances could be extended almost indefinitely, but enough has been recorded here to show that electronics has already served the airplane to an extraordinary degree in control, in all manner of instruments and engine auxiliaries, and in navigation. There is not the slightest doubt, moreover, that electronics will be one of the most important contributing factors in the growth of safety and comfort in post-war flight.

AIRCRAFT PILLOWS

Quickly and Easily Turned Into Jacks

AN INTERESTING new device, developed by the Air Technical Service Command at Wright Field, is simply a giant pillow used to jack aircraft on soft ground or after they have made crash landings. It appears that the idea originally came from our German enemies. The British learned it when they captured some pictures of giant rubber bags being used as airplane jacks. They quickly passed it on to the AAF, and the Air Technical Service Command's equipment laboratory added improvements. One of these is a device for lacing the bags together so that high-wing planes could be lifted to almost any desired height.

The photograph shows and explains the equipment. It weighs 220 pounds and can be carried in almost any airplane. It comprises a set of three bags and one gasoline-engine-driven blower or compressor. Each bag is six feet high and only two are required to lift most airplanes, although a B-24 Liberator takes four

Photo by Air Technical Service Command
Air pillows lift a plane

bags and a B-29 Superfortress takes eight. Each bag can support 12 tons, measures approximately six and a half feet square, and is filled with air at a pressure of three pounds per square inch.

Experience shows that it is far simpler to slip deflated bags under the wings of a belly-landed plane and inflate them than to use the old method of excavating and inserting hydraulic jacks. Even a motorist might at times like to have something of the kind instead of painfully manipulating a conventional automobile jack.

Gas In Bottles

Liquefied Petroleum Gas, Because of its High Thermal Efficiency and Adaptability to Convenient Storage and Transportation, has Come to be an Important Factor in American Economy, Both Domestic and Industrial. Its Uses are Widely Varied and They are Increasing Rapidly

By BUDD MULLOY

ONE of the growing industries in the United States is the production, distribution, and marketing of liquefied petroleum gases—butane and propane. Before LP-Gas became one of the vital materials of war, the annual consumption for domestic, commercial, industrial, and chemical purposes was increasing at an average rate of almost 50 percent a year. While consumption for normal purposes has remained almost static during the war, consumption for war purposes has skyrocketed. New facilities established since 1940 multiply by many times the previous production possibilities.

When early petroleum engineers and chemists were seeking the millenium in a compressed fuel, it lay beneath their feet, regarded as a nuisance in the oil fields and refineries because it produced problems which seemingly could not be whipped. Natural gasoline, for instance, "weathered." So many thousands of gallons of gasoline would be stored in tanks and a great many less gallons could actually be sold. The balance escaped as a gas.

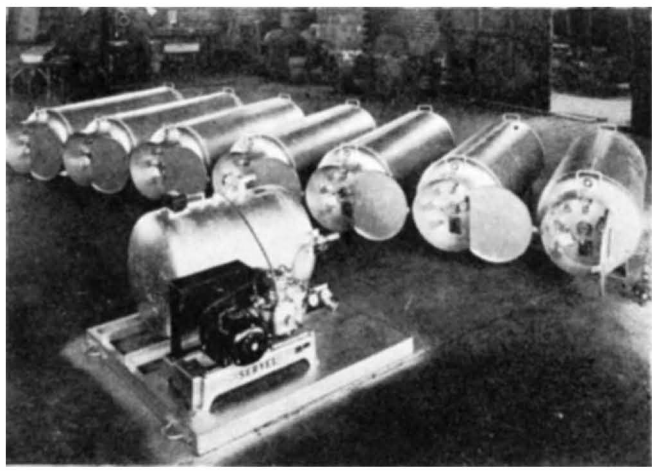
After the turn of the century, the Riverside Oil Company owned nine natural gasoline plants and the general superintendent of the company, A. N. Kerr, determined to stabilize his gasoline and abate the nuisance. He and Herman Stukeman, a young company engineer, worked long and hard on the problem. Finally they decided to condense the escaping gases and in 1910 produced about 200 gallons of the condensate. It proved to be a mixture of butane, propane, and other hydrocarbons.

In 1911, an expert steel cutter, J. F. Richardson, used the new gas to cut steel in Pennsylvania. In May, 1912, the gas was installed in a home and a short time later a Wheeling, Pennsylvania, packer produced liquefied gas for himself and used it to operate one of the early automobiles.

By 1920, butane and propane had been separated and the particular values of each was apparent. Methods of transportation, control, and "packaging" were being tried out. Procedures of selling were getting their first tests. New capital, large and small, entered the business. During the 20's big oil companies created subsidiary companies and chemical companies did the same. All were seeking to capitalize on the growing potentials of LP-Gas as a fuel.

GAS IN LIQUID FORM—The molecular formula for propane is C_3H_8. The designation for both normal butane and isobutane is C_4H_{10}. While both of these arrangements of carbon and hydrogen atoms do much the same industrial and domestic jobs in much the same way, they differ in qualities and advantages. These differences explain the geographic line in their marketing. Of course, markets and uses for the two gases overlap, but two basic factors have contributed to the sectional marketing division. One is the vapor pressure rating; the other what the industry calls the "boiling point." The boiling point of a liquefied gas is that temperature at which it changes rapidly from liquid to gas. It bubbles, or "boils" while so doing, hence the name. The vapor pressure rating of a liquefied gas is the pounds of pressure per

At a war plant, batteries of 100-pound tanks of LP-Gas are manifolded to supply ample gas at required pressure



The manufacture of LP-Gas tanks and systems is an important part of the business of many metal fabricating plants

square inch at a certain temperature.

The great advantage of propane is that the boiling point, where it vaporizes rapidly, is about 44 degrees below zero, Fahrenheit. The disadvantage lies in the fact that its vapor pressure at 70 degrees above zero is 109.3 pounds per square inch. The containers in which it is merchandised weigh, roughly, about as much as the gas in them. Thus 100 pounds of gas sold means 300 pounds of total transportation—the cylinder weighing 100 pounds making a round trip journey in order to sell 100 pounds of gas to the customer.

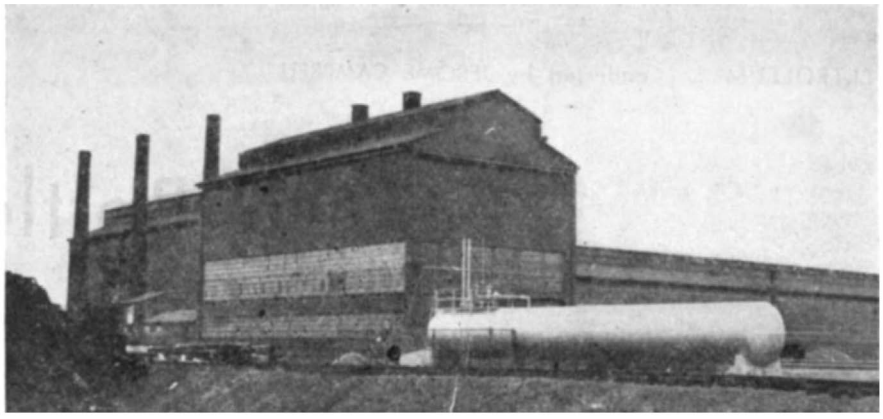
When butane is used in the north it must be protected from the cold, and a system of artificial heating is required, since the boiling point of normal butane is 31.8 degrees *above* zero, Fahrenheit. It readily vaporizes above about 35 degrees and has little, if any, pressure below that level. On the other hand, the pressure per square inch of liquefied normal butane is only 16.9 pounds at 70 degrees. In general terms, this means that butane can be stored and transported in less expensive, lighter equipment than is required for propane.

Most of the LP-Gas sold is not pure propane or pure butane. This lack of "purity" does not mean a lack of virtue or that the product is dirty or undesirable. It means only that it has not been necessary to carry the separation process to the final degree, and that there is butane in the propane and vice-versa. As a matter of fact, many distributors deliberately mix the two gases, to arrive at a blend suited to the area and the climate in which the mixture is sold and the purpose for which it is intended. Butane gas for smudge pots, for instance, is often "needled" with propane to lower the boiling point to the desired figure.

IN THE HOME—More than 2,000,000 American homes today are equipped for cooking, water heating, refrigeration, or room heating with liquefied petroleum gas fuel. These homes are in the suburbs of the cities, in the fringe areas of the large cities themselves, in small cities and towns, and on farms.

The importance of this 2,000,000 home figure is realized by looking at other figures. More than 18,000,000 families in the United States cook with gas of all kinds—natural, manufactured, and liquefied petroleum gas. This means that about one in every nine gas ranges in the country uses LP-Gas.

The gas range used with LP-Gas is much the same as the range used in the city with manufactured or natural gas, but special designing has been done to make the most economical use of the richer fuel. Propane, as it flows to the range, has a BTU rating of 2526 per cubic foot. Butane has 3276 BTU to the cubic foot. The manufactured or natural gas flowing through city gas mains varies in richness, but most of it is about 560 BTU (manufactured gas) and seldom is it richer than 1100 BTU (mostly natural gas).



LP-Gas for this big plant is stored in the large tank in the foreground

Since proper combustion demands that oxygen be supplied in volume somewhat proportional to the richness or heating value of a gas, it is apparent that LP-Gas must have a larger intake of air than city gas. For this reason range manufacturers have designed special burners for ranges sold through LP-Gas dealers. The standard type range can be converted for use with LP-Gas, but those of special design are deemed more efficient.

A family of five persons will use, for cooking purposes, about 8.2 pounds of gas a week if their living scale is in the average bracket, but the amount may double that if the living scale is higher and the family entertains a great deal. A farm family using LP-Gas for cooking and for heating water will use about 14 pounds a week, according to tests. In a Southern home where large quantities of butane are used for room heating and the rate is consequently low, the cost of the fuel used for cooking may be as low as 10 cents a gallon, which is equal to about 2 cents a pound. The other extreme is the summer home in a resort area where only small amounts of gas are used and then only seasonally The price here may be as much as five times higher than the low price level.

In 1928, city gas companies distributing natural or manufactured gas purchased about 1,500,000 gallons of liquefied petroleum gas. This gas was used partially as standby supplies to insure delivery during emergencies and at times of peak load and partially to enrich other gas to keep it up to the set standards of the companies.

Since that year the use of LP-Gas by city gas companies has grown in leaps and bounds. In only two years since 1928 has the record shown a decrease. The other years showed substantial increases, from 10 to 66 percent each year. The 1,500,000 gallons sold in 1928 have grown to 46,000,000 in 1944. Many large cities now have LP-Gas in storage for emergency use and many more are using it to supplement their own gas sales.

LP-Gas is widely used for room heating, particularly in those climates where the weather is not severe but the temperature goes down rapidly after sundown. In these places the job assigned to space heaters is one of taking the chill from rooms. What is needed is a quick, instant heat. Many central heating systems are also operated on LP-Gas.

Room heaters are made in many forms. Among them are the radiant flame type heater, the floor furnace, and hot water or steam radiators with individual gas flame heating units. Some heater models are designed to fit in fire places or wall recesses; some are manually controlled and others automatically operated with thermostats. In size, their input ratings range from 7000 to 60,000 BTU per hour.

While individual room or space heaters are generally designed to be used as auxiliary sources of heat to a central heating system, they are satisfactorily employed for heating entire houses by multiple installation. Butane-propane mixtures are the gases most widely used. For this purpose, a large tank containing from 100 to 1000 gallons of gas is kept outside the house. Piping is run from this tank to each room in the house in which heaters or other appliances are installed.

LP-Gas is used on farms and ranches as a production tool. Wherever heat or flame is required

to boost farm production, or to cut manpower hours, the gas can do a useful job. The tasks assigned to it range from automatic smudge pots for the orchards and flame-throwing weed killers to such prosaic assignments as sterilizing milking equipment and heating chicken hatcheries. In between are the farm-factory jobs such as smoking meat, dehydrating fruits and vegetables, ripening fruits, and fueling the internal combustion engines in tractors and irrigation pumps.

GAS ENGINES—LP-Gas can be used as fuel for internal combustion engines. Some of the early streamlined trains were operated on butane. Railroads use it for compressors, cooking, refrigeration, and to run switch engines. Thousands of irrigation pumps throughout the west use the same fuel and some companies installed butane equipment on the heavy trucks in their fleet as much as 10 to 15 years ago. The buses of the Los Angeles Company were fueled with butane as early as 1930.

Prime advantage of butane and propane as a motor fuel is the fact that they go into the cylinder as a gas and remain so until fired. This means that there is no dilution in the crank case, that the lubricating oil is never stripped off the cylinder walls by the fuel, and that engines may run as much as ten times the normal mileage between overhauls.

A typical case is that of the Spokane United Railways, which converted all its buses to a butane-propane mixture in 1937. Exclusive of unloading and storage facilities, the cost of the change-over was about $250 for each vehicle. The fuel used was a mixture of 65 percent butane and 35 percent propane for summer use and a 50-50 mixture for winter. The temperature in Spokane ranges from —20 degrees, Fahrenheit, in winter to 105 degrees in summer.

Road performance of the Spokane buses has been materially improved over the experience with the same buses fueled with gasoline. Troubles due to vapor-lock were eliminated. Shop maintenance costs were reduced 30 percent. Much of this was because engine overhauls now are made about every 90,0000 to 95,000 miles instead of every 40,000 to 45,000 miles. In addition, it has been found that customers' complaints about obnoxious exhaust odors have been eliminated.

WIDE INDUSTRIAL USE—The abnormal demands for gas in a large midwestern city with many war plants during the past five years has created a fluctuation of gas pressure which upset many of the processes of manufacture. The solution was propane and butane installations at many factories. Constant maintenance of LP-Gas pressure, the assurance of clean, carbonless flames, and the accuracy of control has made a large contribution to the war effort in these factories and foundries. Most of these manufacturers have stated that even when conditions return to normal after the war the LP-Gas installations will stay.

Thousands of manufacturing operations are carried on with LP-Gas. Some of these installations are many years old; others have been born of war necessity. Torpedo hulls made in a Navy-operated factory in Indiana are heat-treated in an oil furnace. Since a draft of cold air coming through the opened door could make them imperfect, a curtain of flame provided by an LP-Gas installation protects the door. Whenever it is opened, tongues of flame shoot from top and bottom to meet and seal the opening against the cold. This is but one of many gas jobs created by the war.

In shipyards of both coasts and throughout the midwest much of the metal cutting is done with propane. LP-Gas, say the shipbuilders, saves time, money, labor, and material. It is reported that the kerf, or cut edge of a plate of metal so cut does not resist a grinder as does a kerf from an acetylene torch. This makes later finishing operations easier. The purchasing agent likes the fact that less gas is bought and the yard superintendent likes the fact that the men do not have to stop their work so often to change tanks. Lay-out men can figure on less metal loss between patterns and can often get an additional and needed piece out of a sheet.

Enamel baking, metal hardening, carburizing and cleaning, smelting and annealing—these are but a few of the additional jobs being done by LP-Gas.

GASES FOR CHEMISTS—The rearrangement of atoms in the molecule and the addition or subtraction of atoms to gain a desired effect is often referred to as "chicken wire chemistry." This reference comes from the molecular diagrams which the chemist draws on his research note pad as his work progresses. Through "chicken wire chemistry" the petroleum chemists and engineers have brought us synthetic rubber, 100-octane aviation gasoline, pigments. They can, and do, take to their work benches butane and propane, the common varieties usually known as "tank" or "bottled" gas, and bring back carbon black, chloroform, pure ethyl alcohol, indigo, formaldehyde, ammonia, and a large number of additional substances.

High test aviation gasoline, upon which our fighting pilots depend for their superiority in the air, represents another large chemical use of LP-Gas. Large quantities of butane and isobutane have gone into the gasoline program. This use might well be considered, too, a stabilizing influence for the industry. Our post-war gasoline will have a much higher volatility and octane rating if a surplus of butane exists. Rather than sell butane stocks at distress prices the refiner will either leave much of the butane in the gasoline or will add it if the gasoline does not already contain enough.

The future of the LP-Gas industry would seem to be one of continued expansion. New markets and new uses are constantly coming to attention; new methods of recovery and distribution are in the offing; and new higher stands of living, plus new industrial processes, will push up and up the figures on the consumption charts.

SCIENTIFIC SEARCHING

For New Oil Sources Required by War Depletions

INTENSIVE post-war "prospecting" by geologists using unusual scientific methods in exploration for new sources of oil and minerals was predicted recently by Professor Paul F. Kerr, head of the geology department of Columbia University.

War demands have called for a great quantity of oil, and have consumed huge deposits of metals. Geologic explorations have expanded supplies of both rare and common minerals as well as fuels, Professor Kerr said, but serious depletion of many of the best deposits will necessitate a quest for new supplies.

The war-time search has developed some new exploratory techniques which still are being kept secret, he added. But the technique of the modern scientific "prospector" already included geologic mapping, sedimentation studies, geochemical analyses of sands and clays found in oil-containing formations, electrical logging, seismic waves, the spectroscope, X-ray identification of minerals, and micropaleontology, the study of microscopic life found even in cores of rocks dug deep from the earth.

Power Plants On Wheels

Comfort in Modern Passenger Trains Requires Large Quantities of Electric Power Put to Work in Many and Divers Ways. On Most Trains, this Needed Energy Is Produced by Car-Mounted Generators Driven by the Axles. Other Methods Are Also Used

By A. G. OEHLER
Electrical Editor, *Railway Age*

PASSENGER locomotives have many functions in addition to hauling cars. One of the most important of these auxiliary duties is the generation of electric power, usually by means of axle-driven generators mounted on the cars.

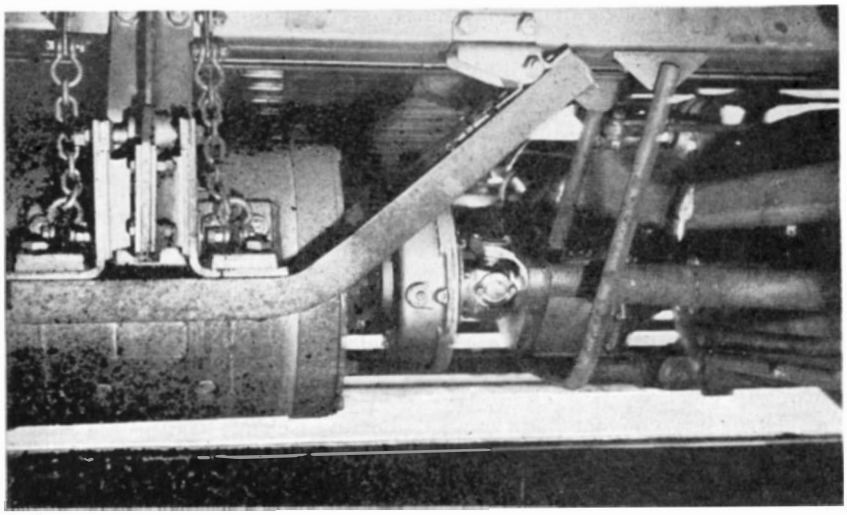
A modern passenger train needs huge quantities of electricity for lights in the cars and on the locomotive; for the ventilation, refrigeration, and controls required for air conditioning; for cab signals or automatic train control; for accurate control of high-speed brakes; for refrigerators and gadgets in the diner; for water-coolers and electric razors in the Pullmans; for the radio in the lounge car; and perhaps also for a train telephone system.

All this necessary auxiliary power is generally created by the locomotive, though on some roads it may be generated by a propane-fueled engine under the car or by one of several Diesel-generator sets in a power car next to the locomotive.

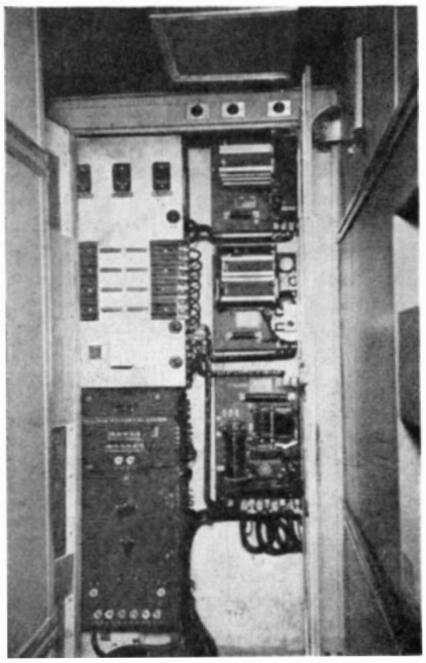
In the United States 6300 steam locomotives are used for hauling passenger trains. This represents about 16 percent of a total of 39,500 used by Class I railroads; 296, or 38 percent, of the country's 868 straight electric engines are used in passenger service; out of a total of 2500 Diesel-electric locomotives there are 287, or 11.5 percent, used in passenger and in combination and freight service. The low percentage of the Diesels used in these categories is explained by the relatively large number used for switching.

Most of the 8729 Pullmans and 35,945 railroad-owned passenger train cars in service today are electrically lighted; 5219 Pullmans and 8139 railroad-owned, a total of 13,358 cars, are air-conditioned. In one form or another, each one of these cars requires from one to thirteen kilowatts of power for the comfort and convenience of the passengers—power that is not used for moving the car.

If a car is equipped with electromechanical air conditioning, it has a 20-kilowatt generator driven by gears, or V-belts and gears, from one of the car axles. Although the connected load in the car is only 10 or 12 kilowatts, the generator must be of 20-kilowatt size because the train is standing for a part of the time, or running at speeds too low to develop full generator load. To compensate for this, the generator must have sufficient surplus capacity to charge a storage battery for use when the train is standing.



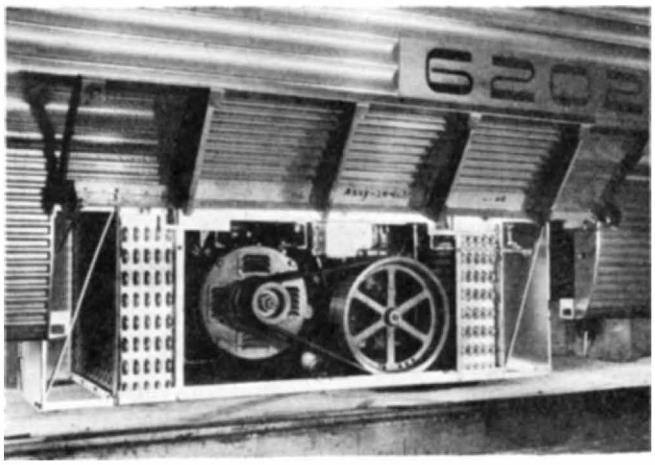
An axle-driven generator attached to the bottom of a car, showing the automatic clutch, a universal joint, and the splined shaft extending to the gears on the axle



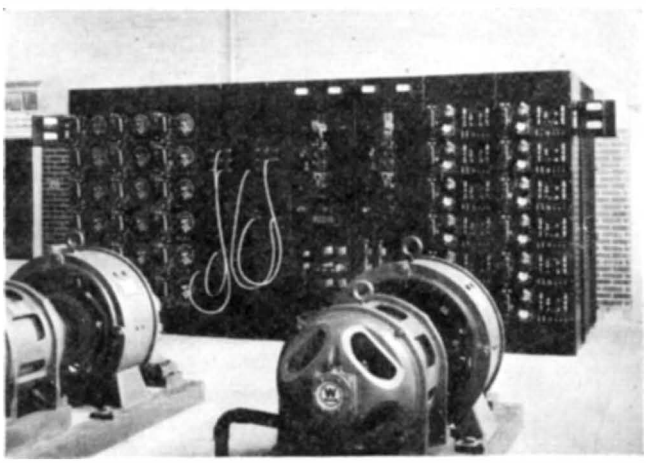
Crowded together in orderly fashion in this locker are all the electric controls of a modern passenger car

Consequently, there must also be standby power systems in yards and terminals for charging batteries and for operating air-conditioning equipment.

When the 20-kilowatt generator operates at full capacity, it requires about 40 cylinder horsepower of the locomotive. Thus if there are ten air-conditioned cars with loaded generators in a train hauled by a



Hidden under a streamlined car is the air conditioning unit with its condenser and its motor-driven compressor



An installation of motor generator sets, with their switchboard for charging railroad car batteries in the yards

4000-horsepower locomotive, the auxiliary power required may amount to 10 percent of the capacity of the locomotive.

CAR LIGHTING—Fluorescent lights are now being used extensively because they offer a number of advantages over incandescent lamps. Their shape makes them readily adaptable to the long, low interiors of a car. They reduce the load on a limited supply system and generate less heat, thus reducing the load on the air-conditioning system.

Most of the available fluorescent lamps operate on 115-volt, 60-cycle power and this means that the direct current from the generator, usually at 32 volts, must be converted either by a motor-alternator or a vibrating inverter. A 15-inch, 14-watt lamp was developed for direct-current operation on 64-volt systems, but its use also requires some loss in a series control resistor for each lamp.

The 32-volt system is most widely used on railroad trains, but growing loads have called for battery sizes which make handling difficult and for unwieldy and expensive conductors. As a result, there will probably be an increasing use of 64 and 115-volt systems.

Engine-driven generators and compressors have found increasing favor on western roads in recent years. In this system, two identical, 20-horsepower, propane-burning engines are used to drive respectively a 7½-kilowatt generator and a compressor to supply the needs of the car, thus relieving the locomotive of the air-conditioning and lighting load.

One train has been built with each car having a power plant which supplies all electrical needs including heating. A Diesel engine under each car drives a 30-kilowatt generator for lighting, air-conditioning, and other needs. When heat is required, this is obtained from electrical resistors and from engine jacket water.

There are two kinds of head-end power systems. One is represented by a train having a power car containing two 300-kilowatt, Diesel-electric generating sets. This is coupled next to the locomotive and supplies all electrical requirements of the train through train lines at 220-volts, three-phase. A 64-volt battery on the power car is charged by a motor-generator set and another on the observation car by a vacuum-tube rectifier. A 64-volt direct-current train line supplies emergency lighting, control apparatus, and air brakes.

The second type of head-end power system is in use on a few suburban trains which are successfully lighted by a steam turbine-driven generator mounted on the locomotive. No batteries are required, but cars cannot be cut out of the train without interruption of the lighting.

PASSENGER COMFORT — Air-conditioning controls on railroad systems are being constantly improved. At first passengers were happy with a little cooling. Having grown accustomed to comfort, however, they became critical. It is now necessary to have controls which modulate the cooling effect in steps, causing the inside temperature to follow the outside at a respectful distance, and keeping all cars in the train at the same temperature. It has also been found desirable to make the controls almost fully automatic.

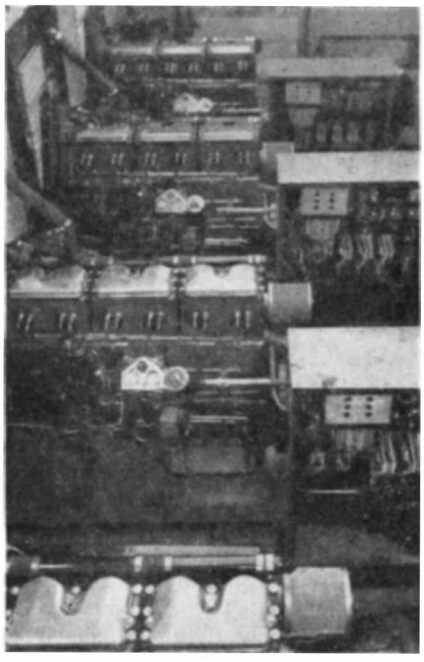
Dirt is kept out of cars by filters, either the oiled type which is cleaned periodically or the dry type which is replaced when necessary. More recently there has been tested on two cars an electrical precipitator which effectively removes solid particles as small as tobacco smoke.

Odors are another railroad-car problem. These can be absorbed by activated carbon, and can be removed, or masked, by various types of deodorants. The introduction of ozone, properly regulated, is effective.

Humidity control is in most cases a by-product of temperature control. When air is cooled by the coils of the evaporator, water is precipitated on the coils and is drained off. In earlier types of air conditioning, full cycling control was used; the compressor ran at full capacity or it did not run, as dictated by a thermostat. Under these conditions the humidity will rise during off-cycle periods, causing some moisture to form on the skin of passengers even though the rise in temperature is slight. Although rate of air circulation remains constant, when the compressor starts again and the evaporator coils start collecting moisture, evaporation of moisture on the passengers increases and they feel a sensation of cold.

To correct this condition, evaporators are divided into two parts and compressors are run at two or three rates or capacities, thus step-modulating the system to make cooling and dehumidifying continuous at all but very light loads. The ideal condition, however, is obtained by reheating. This requires that the compressor be run constantly at full capacity with a small amount of steam heat used to bring the temperature back to the required value. Reheating has the disadvantage of putting more load on a limited power supply system, but has been used effectively in climates where the humidity is high.

REGULATION—Power control in a car is in all cases centralized in what is known as an electric locker. Here are assembled voltage regulators, automatic relays, main switches, distributor panel, air-conditioning controls, and other auxiliary devices. Unfortunately



Four 50-kilowatt Diesel generators are mounted in this train power car

for the circuit designer, the locker must be placed at one end of the car. From this location conduit lines by the dozens disappear through the floor to the underneath areas and also up into that vast, mysterious, and well-filled space above the ceiling which the passenger never sees. There the electric layout man competes with those who are trying to hide water lines, train lines, brake systems, air piping, tanks, steam lines, and many other things, remembering the while that an adjacent steam line is an effective way to preload a circuit. The modern sleeping car, too, must provide separate rooms complete with all toilet facilities, and is made with thin solid partitions to conserve space.

WHAT'S COMING—Prophecy is always unsafe, but there are already many indications of future trends. The war-time traffic has required that the railroads employ every passenger car they could put into safe operating condition and to use them so intensively that it has often been necessary to turn them around at terminals without sending them to the yards for cleaning. Loading has increased to the point where passengers sit three in a coach seat, with others sleeping in the aisles and even in the baggage racks. Wear and tear has increased accordingly, and the railroads have not yet been allowed to build any new cars.

There are more than a thousand cars on order, waiting until material can be released for their construction, and it is estimated that the passenger train cars to be ordered during the first five years after the war may well approach the total attained in the early 1920's when the average was about 2024 per year.

"Standard Pullmans" with curtained compartments will gradually be replaced with various types of room cars. Many innovations in the form of diners, club, lounge, cafe, and observation cars will appear; even a nursery car has been planned. The preponderance of new cars, however, will probably be coaches since railroads are particularly well situated to supply transportation in large units. The coaches built recently, too, have been notable for supplying more comfortable travel than the chair and lounge cars of some years ago.

Trains will be faster and cars will ride better because of improved design and construction which may even employ such refinements as gyro stabilizers. Electrical operation of service brake applications becomes desirable as train speeds go up. Electrically controlled devices to prevent wheel slipping are used to a limited extent and their application will undoubtedly be extended. Diners will use electric refrigeration and may employ electric cooking; a 50-kilowatt axle-driven generator is being considered for use on a diner. Several designs have also been made for Diesel-electric power plants to supply complete needs of individual cars.

Air conditioning for new and remodelled cars will include many refinements and there will be more automatic control. Models and drawings of new car interiors indicate that new lighting installations may well serve to show the traveling public how lighting can be used advantageously in the home. Gadgets such as grilles, toasters, percolators, mixers, dishwashers, and so on may be expected to appear in considerable profusion. Radio and inductive train telephone systems for communication between opposite ends of a train and between trains, as well as trains and wayside points, will be applied first to freight service, and will later be used to expedite the movement of passenger trains.

CAR SPRINGS

Studied Through Window In the Car Floor

STANDARD freight-car trucks have coil springs with a maximum travel of 1⅝ inches from free height to solid. These trucks pass through critical speeds usually between 45 and 50 miles an hour where the rate at which the wheels pass rail joints coincides with the natural period of vibration of the loaded truck springs.

The need for longer-travel springs in freight-car trucks intended for high-speed service was established in a series of tests conducted by the Association of American Railroads. In efforts to develop a satisfactory truck conforming to the principles established by the earlier tests, the American Steel Foundries employed two freight cars elaborately equipped with apparatus for the measurement of various truck and car-body movements and of shocks transmitted to the car body. Notwithstanding extensive data available from indicating and recording instruments, visual observation of the action of the trucks was still considered an important part of the tests. Hence windows were placed in the floors of the cars on each side of each truck.

In the development and proof testing of its speed-control truck the American Steel Foundries' cars were run 50,000 miles. The truck includes springs with a maximum travel up to 3-13/16 inches with just enough friction damping action to discourage violent bouncing in the critical speed range.

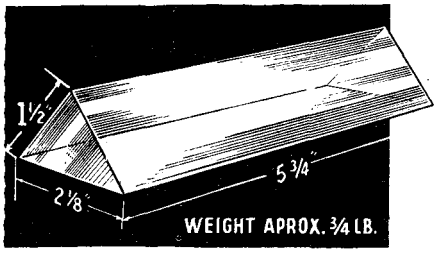
RAILROAD RESEARCH

Coal Mines Take a Hand In Locomotive Improvement

A RESEARCH project to improve the coal-burning locomotive was launched in January by six railroads and three major coal-producing companies. More than a million dollars has been subscribed to initiate the research which will be handled by Bituminous Coal Research, Inc., an agency of the bituminous coal industry, as a distinct project with separate personnel administered by a committee of which R. B. White, president of the Baltimore and Ohio Railroad, is chairman. Bituminous Coal Research, Inc., has under way a study of combustion in the locomotive boiler at the Battelle Memorial Institute.

The railroads involved in the new project are the Baltimore and Ohio; the Pennsylvania; the Louisville and Nashville; the Norfolk and Western; the New York Central; and the Chesapeake and Ohio. They originate more than 60 percent of the bituminous coal tonnage moved by the railroads. The three coal producers are the Island Creek Coal Company, M. A. Hanna, and the Sinclair Coal Company.

TERRIFIC BARGAINS IN WAR SURPLUS LENSES AND PRISMS



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3006-S	Porro Abbe Prism	$.25 each
3016-S	Pentagon Prism	.75 each
2024-S	10 Pieces Circular A-1 Plate Glass (Diam. 31 mm. — for making Filter)	.25 each
1004-S	2 Reducing Lenses	1.20
3001-S	Lens Surface Prism	2.00 each
503-S	No. 1 Sable Hair Lettering Brush	1.00 doz.
3021-S	Amici Roof Prism (3rd Grade)	.25 each
4009-S	Heat Absorbing Glass 4" x 5"	.35 each
4010-S	Heat Absorbing Glass 2" x 2"	.10 each
2016-S	17 mm. Diam. Gunsight Reticle	.10 each
2020-S	40 mm. Neg. Lens, Cross Lines	.25 each
3020-S	Right Angle Prism 48 mm. wide (3rd grade)	.35 each
523-S	Six Threaded Metal Reticle Cells	.25
26-S	First Surface Aluminized Mirror, Diam. 1¼"	.25 each
1027-S	Perfect Plano-Convex Lens, Diam. 12.5 mms., F.L. 20 mms.	.30 each
624-S	Neutral Ray Filter size 4¾" x 2½"	.25

(Minimum Order on Above — $1.00)

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1 Red and 1 Yellow Filter in following Diam.
20 mm. (seconds) **40c** 31 mm. (seconds) **70c**
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Stock No.	Dia. in mms.	F.L. in mms.	Comments	Price
6019-S	15	41	Cemented	60c
6111-S	16	36	Cemented	75c
6094-S	16	75	Cemented	$1.00
6066-S	32	132	Uncemented	75c
6115-S	46	108	Cemented	$1.00

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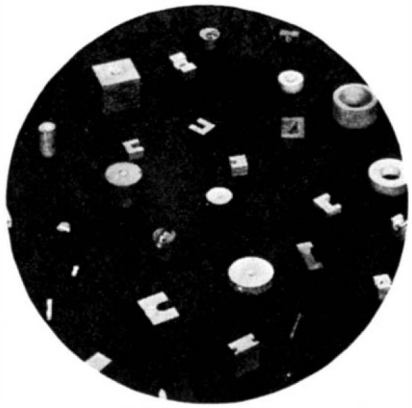
Industry's Permanent Pull

Modern Permanent Magnetic Alloys, Two to Ten Times More Powerful Than Former Materials, are Responsible for Compact, Efficient War-Time Energy-Converting Devices and Will be the Key Elements in Many Post-War Electrical and Electronic Products



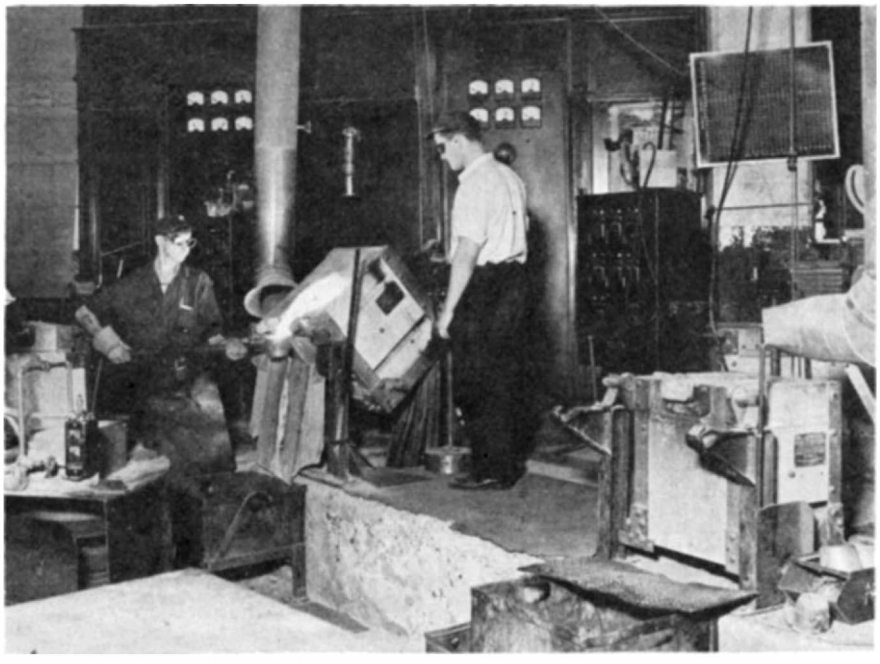
Courtesy General Electric Company
An array of sintered Alnico magnets

ALTHOUGH hardly a new device, the permanent magnet has won so many new friends and entered so many new fields in recent years as to be truly a "modern" electrical accessory. This is especially true of those made of the newer permanent magnet materials, with the unusual design, performance, and cost advantages they provide.

Permanent magnets are the essential components of many of the familiar conveniences of our everyday life as well as of the more utilitarian necessities of industry. Phonograph pickups, radio microphones, electric guitars, automobile magnetos, generators and motors, radio loudspeakers, electric power meters, magnetic separators, magnetic chucks, and thermostats, are among the items of modern living that are more effective because of the highly developed state of permanent magnet materials.

A permanent magnet is a product that retains a large part of the magnetism induced in it when "magnetized" (it has a high "coercive force") and which can then exert a very high magnetic force on other magnetic materials. Permanent magnet materials are said to be magnetically "hard," in contrast to the magnetically "soft" metals like pure iron which are much more easily magnetized (they have higher "permeability") but retain very little magnetic force when the magnetizing energy is removed.

Permanent magnets have been so increased in effectiveness and efficiency in recent years that they are replacing electromagnets in some devices. Nearly everyone has seen, heard of, or wondered about the tiny permanent magnets which can lift 60 times their own weight. Such magnet materials are responsible for some of the most compact and efficient energy-converting devices in war-time use and will be key elements in many of our new post-war electrical and electronic products.



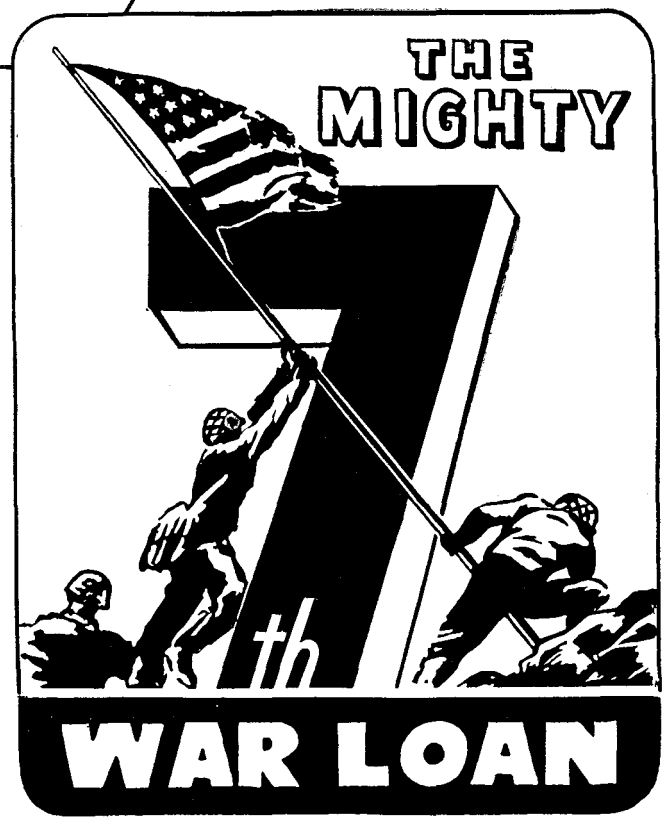
These workmen are pouring molten Alnico. High-frequency induction furnaces are employed in this work because they permit close control of composition and cleanliness

The general applications of permanent magnets fall into three major classes, according to purpose: (1) converting mechanical to electrical energy; (2) converting electrical to mechanical energy; and (3) tractive effort—lifting or holding or pushing or pulling materials or apparatus parts.

In converting mechanical motion to electrical energy, the permanent magnet produces a magnetic field through which a moving conductor passes, thereby generating electrical energy (or the conductor may be stationary, with the magnets rotating). The most familiar examples of this are the electric generator, the dynamic microphone, and the phonograph pickup.

In converting electrical energy to mechanical, electric current is passed through a conductor located in the field of a permanent magnet so that whichever is rotatable or movable, moves. Electric motors are a classic example of this, with loud speakers a typically modern use (and prior to the war the number 1 outlet for permanent magnets on an

IT'S UP TO YOU TO HELP MAKE 2=3 WITH...



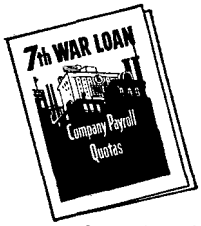
A job for seasoned executives—this 7th War Loan! Especially when we've got to make 2 war loans total just about as much as all 3 in 1944! Putting this over demands the combined and *continued* efforts of the "No. 1" men of American industry.

This means marshaling your plant drive to make every payday—from now 'til June 30th—do its share toward the success of the 7th. Directing the drive is not enough. It's equally important to check to see that your directions are being carried out—intelligently!

For example, has every employee had:

1. **an opportunity to see the new Treasury film, "Mr. and Mrs. America"?**
2. **a copy of "How To Get There," the new Finance Division booklet?**
3. **a new bond-holding envelope with explanation of its convenience?**
4. **7th War Loan posters prominently displayed in his or her department?**
5. **information on the department quota—and an urgent personal solicitation to do his or her share?**

Remember, meeting—and beating—your highest-yet 7th War Loan quota is a task calling for "No. 1" executive ability. Your full cooperation is needed to make a fine showing in the 7th! Do not hesitate to ask your local War Finance Chairman for any desired aid. It will be gladly and promptly given.



If you haven't a copy of this important booklet, "7th War Loan Company Quotas," get in touch immediately with your local War Finance Chairman.

The Treasury Department acknowledges with appreciation the publication of this message by

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annual poundage basis). Telephone receivers, magnetic recording heads, polarized relays, and similar devices also employ permanent magnets in this way.

TALKING TAPES—Although the Bell Telephone Laboratories has used endless loops of alloy tape for magnetic sound recording for some years in their weather announcing systems, the advent of the war has brought renewed interest in this field. The United States Army is now using tape for recording "on the spot" developments. The records need not be processed but can be played back immediately.

A successful magnetic alloy for this application is "Vicalloy," containing 6 to 16 percent vanadium, 30 to 52 percent iron, 36 to 62 percent cobalt. This alloy holds more permanent magnetism than any other commercial material and, moreover, can be rolled and drawn into a thin flexible tape. A special heat treatment is required to develop suitable magnetic properties.

The third functional field of use—tractive effort—is the one most familiar to the average reader and the one in which permanent magnets sometimes replace electromagnets. Here the magnetic force of the permanent magnet is used directly to attract magnetic material or other magnets. Magnetic chucks for holding work on a lathe and magnetic separators for extracting unwanted iron from nonferrous metal scrap are well-known holding or lifting devices using magnets; a ubiquitous tension-producing application is the thermostat, in which the magnet provides a quick make or break in the electrical circuit without the use of mechanical springs. The packingless drive represents the use of permanent magnets for transmitting motion without mechanical connections.

The original permanent magnets were made of hardened high-carbon steel. Then for many years the best materials were a 3½ percent chromium steel and a 5 to 6 percent tungsten steel. These have been over-shadowed in importance in recent years by the so-called cobalt magnet alloys and most recently by the Alnico materials containing aluminum, nickel, and iron, with or without cobalt or copper.

For reference purposes the properties of commercial permanent magnet materials are given in the accompanying table. The $B \times H_{max.}$ figure is the so-called energy-product of a permanent magnet material and is the usual measure of its efficiency as a permanent magnet. Note the great difference between this value for the older materials at the top of the table and for the more recent alloys near the bottom. Alnico V is a truly phenomenal alloy, being about three times as powerful as any other permanent magnet material.

An Alnico permanent magnet acts as the heart of this radio loudspeaker

PROPERTIES OF COMMERCIAL MAGNET ALLOYS

MAGNET ALLOY	TYPICAL COMPOSITION, %	$B \times H_{max.}$	MECHANICAL PROPERTIES	FEASIBLE METHODS OF FABRICATION
Chromium steel	3.5 chromium, 1 carbon, balance iron	295,000	hard, tough	forged; punched; machined
Tungsten steel	5 tungsten, 1 carbon, balance iron	320,000	hard, tough	forged; punched; machined
17 Cobalt steel	17 cobalt, 1 carbon balance iron	650,000	hard, tough	forged; punched; machined
36 Cobalt steel	36 cobalt, 3.5 chromium, 1 carbon, balance iron	930,000	hard, tough	forged; punched; machined
Cobalt-nickel-copper Alloy	41 cobalt, 24 nickel, 35 copper	993,000	ductile	cold-rolled; machined; punched; cast
Iron-nickel-copper Alloy	20 iron, 20 nickel, 60 copper	1,070,000	ductile	cold-rolled; machined; punched
Cobalt molybdenum Alloy	12 cobalt, 17 molybdenum, balance iron	1,100,000	hard, tough	forged; cast; punched; machined
Alnico I and IV	12 aluminum, 20-28 nickel, 5 cobalt, balance iron	1,250,000-1,330,000	hard and unmachinable	cast; sintered; ground
Alnico III	12 aluminum, 25 nickel, balance iron	1,330,000	hard and unmachinable	cast; sintered; ground
Alnico II	10 aluminum, 17 nickel, 12.5 cobalt, 6 copper, balance iron	1,650,000	hard and unmachinable	cast; sintered; ground
Alnico V	8 aluminum, 14 nickel 24 cobalt, 3 copper, balance iron	4,000,000-4,500,000	hard and unmachinable	cast; ground

MORE POWER, LESS BULK—This extra potency of the modern materials and especially the Alnico alloys has vastly improved magnet design in several respects. A most important feature is the smaller-sized magnets that can be used because of their greater magnetic force, as shown in the accompanying bar chart.

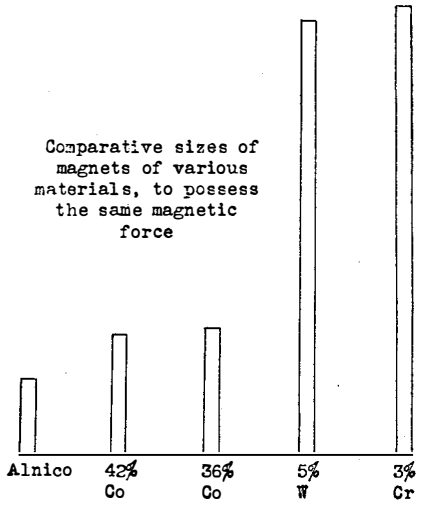
In the case of the newer materials the increase in energy product over the old is proportionately much greater than the increased cost, with a consequent reduction in cost per unit of energy product. Thus the chromium magnet steel may cost three times as much per unit of energy product as Alnico V. On the other hand, such cost-of-performance advantages of an alloy may be partly or wholly offset by the extra cost of fabricating or finishing the magnet itself, since the new alloys are more difficult to work.

The decrease in space required, together with the lighter weight, has frequently justified higher permanent magnet cost. In addition, the Alnico magnets are more resistant to demagnetization (often an important factor) either by vibration or by stray magnetic fields than are the older alloys. The new materials show little loss of magnetic force at temperatures up to 900 degrees, Fahrenheit, whereas the alloy steel magnets suffer appreciable losses as

low as 200 to 400 degrees, Fahrenheit.

The new materials require different production techniques than were commonly used for the alloy steel magnets. All depend for their magnetic qualities on appropriate heat treatment or "age hardening." For the older materials this may be simply quench-hardening; for the newer alloys the magnet is heated to a high temperature to produce a homogeneous structure and then either (1) quenched and held at a dull red heat for a long time to produce a "precipitated" structure possessing optimum magnetic quality (and, incidentally, higher hardness) or (2) slow-cooled from the high temperature to produce the same structure and properties. The second process is more commonly used with the Alnico alloys.

NEW METHODS—The other differences in processing are radical. The tungsten or chromium magnet steel in the form of cut rod or bar is hot-formed to shape on a press, cooled,



Comparative sizes of magnets of various materials, to possess the same magnetic force

drilled, and machined while soft, heated to hardening temperature, quenched and ground to final dimensions. Such methods cannot be used to make magnets from Alnico, for the latter alloys are hard, brittle, unmachinable materials that can be made only by casting nearly to shape and then grinding, or by powder metallurgy methods (pressing metal powders in a die and sintering).

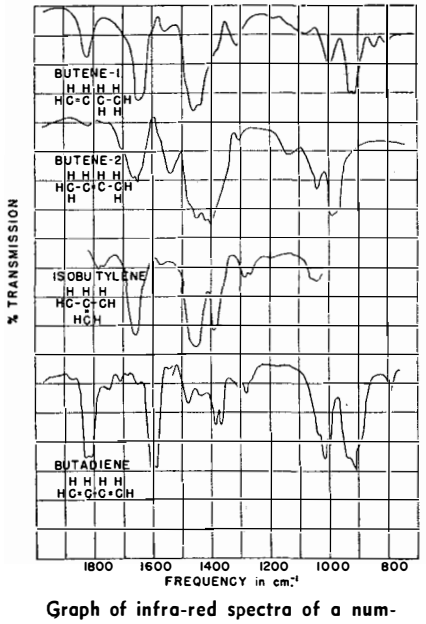
The sintering process is ideal for small magnets of certain designs but has definite limitations above a certain size (about 0.1 pound), and the bulk of Alnico magnets are therefore made by casting and grinding. The magnetic properties of cast and of sintered Alnico of the same composition are about the same. The cast magnets require

(*Please turn to page* 49)

Infra-Red In Industry

By Harnessing Forces that Act Outside the Bounds of Human Senses, and Applying Electronic Amplification, Chemical Control Methods Have Been Highly Refined. The Infra-Red Technique is Not Yet in Wide Use, but Successful Results So Far Point to Broad Future Fields

As PROBLEMS of continuous and automatic processing in the chemical industry become more complex, electronic devices grow in stature. In addition to utilizing heat and pressure, control today depends upon factors quite imperceptible to the human senses to motivate operations requiring substantial power in their performance. Forces too faint to be detected by less sensitive means are magnified by electronic circuits until they are able to activate the necessary controlling mechanisms to keep the process within bounds.



Graph of infra-red spectra of a number of C_4 unsaturated hydrocarbons

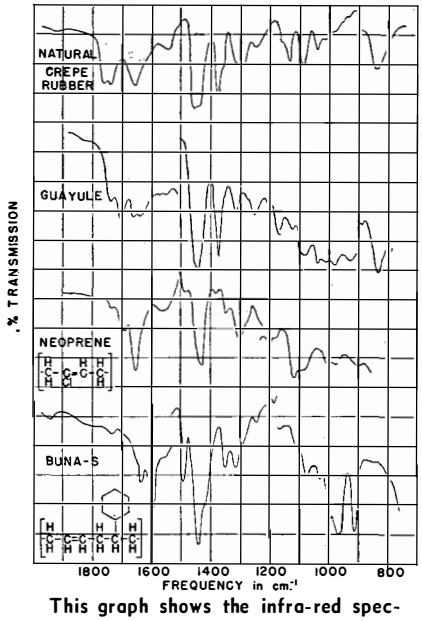
Indeed, the initiating forces may, by their very nature as well as their magnitude, be quite outside the range of our senses and yet be capable of carrying on a chemical reaction in huge amounts of material with far greater assurance than a human operator possibly could. Typical of this class are control functions based upon ultra-violet absorption, pH values of solutions, and infra-red transmission, none of which is normally detectable by the human senses. While the detection and even the measurement of these values can be accomplished without using electronic equipment, conversion of detectors and meters to practical controlling devices requires electronic amplifying circuits.

In this field, the swiftness of scientific development and its application outside the laboratory to plant operating problems are particularly well illustrated. Although many of the basic facts about infra-red absorption and its relation to chemical structure have been known for several decades, their use in the laboratory is still far from general. Only within half a dozen recent years has this technique begun to spread, yet it already has been adapted to the control of important industrial operations.

Current huge scale chemical conversions of the hydrocarbons of petroleum into aviation gasoline on the one hand and into synthetic rubbers on the other have entailed delicate problems of analysis and what seemed only a short time ago to be insoluble problems of control. But both analysis and continuous control of processes have been accomplished with an ease and completeness that suggest further wide applications of the methods employed.

CHEMICAL FINGER-PRINTS—Various hydrocarbons in mixtures can be measured separately by the use of the mass spectrometer, provided there is even the slightest difference in their atomic weights. The method is based on inducing unit electrical charges on the molecules, comprising the unknown gaseous mixture, accelerating the charged particles in an electric field, and finally bending their paths from the normal straight lines by imposing a magnetic field on them. The extent of the curvature of the path is a function of the mass of the particle, as well as its charge, and hence this factor provides a method of distinguishing among the hydrocarbons in a mixture. Furthermore, it is possible—but not yet practicable—to employ this method of effecting an actual separation of molecules of different weights.

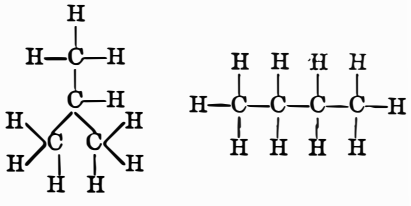
This method, valuable though it is, fails where the hydrocarbons constituting the mixture are isomers having identical molecular weights. Special emphasis is placed on the several hydrocarbons of four carbon atoms in both aviation fuel and rubber synthesis. Obviously, then, a method must be employed which



This graph shows the infra-red spectra of natural and synthetic rubbers

will not only distinguish between the butanes and butenes and other hydrocarbons in such mixtures, but it must also recognize differences between butane (CH_3-CH_2-CH_2-CH_3) and isobutane (CH_3-CH-(CH_3)$_2$), and between the two butenes (CH_3-CH = CH-CH_3 and CH_2 = CH-CH_2-CH_3) and isobutylene, (CH_2 = C-(CH_3)$_2$). Necessarily such distinctions rest on molecular structure alone and their detection can be effected only by a method taking this into account. That is where infra-red absorption finds its natural field because each atomic group within a molecule exerts a characteristic effect on the compound's absorption for infra-red radiation of a characteristic wavelength. The graphic representation of the transmission of infra-red of different wavelengths through any compound is quite as characteristic of the compound as the signature or fingerprint is of a person.

That is particularly important where compounds so similar as the C_4 hydrocarbons are involved. Furthermore, on the basis of differences in the absorption spectra, the relative quantities of each constituent in a mixture can be estimated



On the left, the structural formula of isobutane and, right, of butane

with considerable ease and accuracy. By selecting a particular part of the spectrum (a narrow band of wavelengths) and using it to activate the controlling mechanism, the infra-red transmission of the mixture, and hence the percentage of a particular compound in it, can be used to control the manufacturing process.

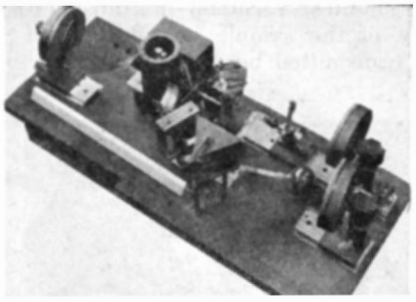
Special peculiarity of infra-red radiation is the opacity which many materials exhibit to it. Because many substances have characteristic absorption spectra in this region, particular care must be exercised in choosing the construction materials of the instrument and in excluding any compounds from the path of the rays to be measured that might affect them. Where examinations of organic compounds are to be made, carbon dioxide and water vapor must be carefully excluded from the body of the instrument through which the rays pass or, better, the effect of them allowed for in the result.

The instrument itself consists essentially of a source of infra-red radiation of all wavelengths (a hot body), a sample, a prism for dispersing the rays (made of sodium chloride or other substance transparent in the range of wavelengths being investigated), and a sensitive thermocouple to detect and measure the final radiation. Sensitivity is greatly improved by using concave mirrors to focus and direct the rays and to concentrate the final pencil of rays on the thermocouple for measurement. The voltage generated in the thermocouple by the heating effect of the rays is detected and measured by an extremely sensitive galvanometer from which a graphic record of the transmitted spectrum is taken with the help of an amplifying circuit employing electron tubes.

AMPLIFICATION IS THE KEY— For purposes of control, the intensity of the radiation from a constant source transmitted through the sample at a single selected wavelength is measured by the thermocouple and amplified in an electronic circuit to an extent sufficient to operate the necessary mechanism. The slightest variation in transparency of the sample is reflected in the transmitted beam. Amplification

of the feeble initial impulse allows a remarkably effective control to be worked out and applied to even the complicated equipment of both the aviation fuel and the synthetic rubber industries.

Once the transmitted infra-red ray has been detected and its effect amplified, the remainder of the controlling mechanism and its plan are identical with those based on pressure, temperature, and other less abstruse variables. The objective of all such arrangements is to exercise control over an operation in continuous progress and to make it so quickly effective that the process has no opportunity to get out of hand.



Infra-red spectrometer without cover

In the petroleum chemical industry, for example, automatic control is vital to most processing steps. These are commonly carried out in continuously flowing streams of gas or liquid as they move through heated or cooled zones and past catalysts which influence fundamentally the chemical changes occuring. Because these processes are practiced on a vast scale, the slightest variation from the established values for even a tiny interval of time may waste important amounts of materials or even, in the extreme case, lead to disaster.

The plant operator strives to conduct his processes at just the point of greatest yield of his desired product and this may fall on a narrow edge of efficiency between areas of wasteful under- and over-conversion. This is particularly true with such delicate reactions as that which converts various hydrocarbons into butadiene, essential raw material in synthetic rubber. The desired product is more delicate and unstable than any of the other compounds likely to be present and hence is readily destroyed if conditions are not controlled with great precision in the narrow optimum range.

EFFECTIVE INSTRUMENTATION—The same thing is true in varying degrees of all chemical processes. Under one set of conditions they proceed in an efficient and orderly manner and can be conducted continuously with high output. If critical variables are allowed to drift outside optimum ranges, continuous processes become wasteful in the extreme. Seldom can human operators respond with the requisite speed to the demands of the process and hence it is out of the question to attempt to design or operate an automatic or continuous process until effective instrumentation has been developed for it. In this respect, electronic amplification has proved a tremendous boon to the industry. Necessarily the variation of any factor required for control must be tiny to prevent trouble and that requires extreme sensitivity in the controller; but, at the same time, the force required in exercising any control is entirely out of proportion to the power usually available from a sufficiently sensitive unit. That makes an ideal field for electronic amplifiers; industry, made to realize their high value by their performance on wartime tasks, will be quick to use them in post-war operations.

Having used infra-red spectroscopy as an example of electronic control in the chemical industry, it would be negligent not to describe more of the important uses of this valuable tool. A decade ago, infra-red spectroscopy was so unfamiliar to even the scientist that it was considered scarcely more than an abstruse scientific toy. Within the intervening few years, its value has been so proved on both military and civilian problems that few research laboratories will be able or willing to get along without its help. Developments in the instruments based upon it have progressed to the point where simplified models now available are sensitive as well as rugged and sturdy, qualities absent from their earlier prototypes in the scientific laboratories. The present instruments can be readily used in the normal plant environment whereas the older infra-red spectroscopes required to be isolated in a virtual dungeon to get away from disturbing influences.

TIRES ANALYZED—Already mentioned has been the problem of distinguishing between the C_4 hydrocarbons by the infra-red method as one of its outstanding achievements. Quite as striking was its use to analyze tires captured from the Germans to determine their content of natural and synthetic rubbers and the kinds of synthetic used. With infra-red methods this question was settled in a few hours whereas it might have required weeks by other methods, if indeed it could be solved at all. Production of toluene from petroleum has become quite as vital to our war-making potential as that of synthetic rubber. It, too, presented a problem in analysis and control which yielded quickly and easily to infra-red spectroscopy but was extremely tedious and difficult by more usual methods. There are many other examples only a little less striking.

The intricacies of many organic compounds have been revealed by these methods. Each part of the complex structure of an organic chemical compound affects the absorption of infra-red at a characteristic wavelength and thus supplies invaluable clues to the entire structure by showing what parts compose it. The different effects of different atomic groups within the molecule are characteristic and are affected only slightly, if at all, by other groups present. In the hands

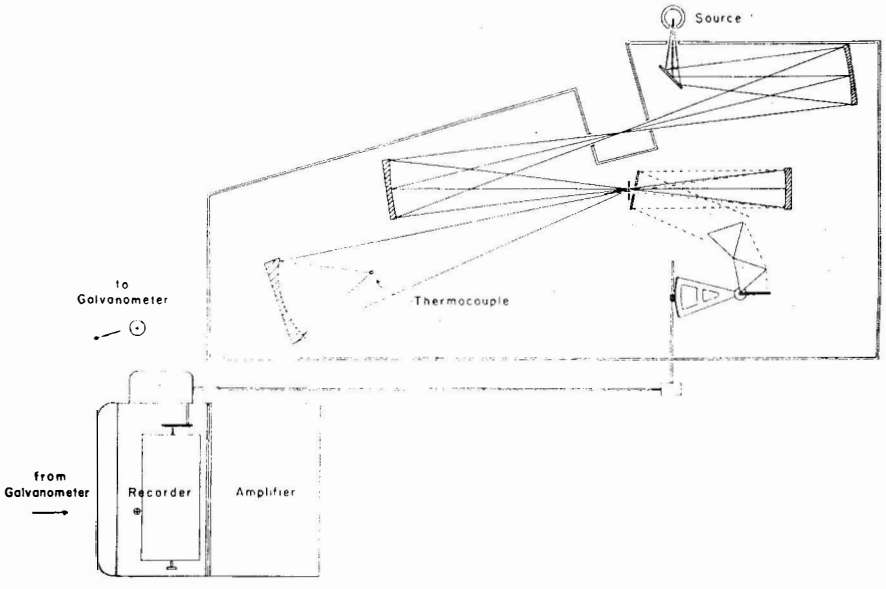


Diagram showing essential parts of an infra-red spectrometer

of an experienced worker, an infrared spectrogram becomes a virtual blue-print of the structure of the compound. The extraordinary variety of the spectra produced by the many thousand organic compounds employed in today's industry makes this the most effective method of distinguishing between them. Furthermore, the known relationships between structures and spectra provide the keys to the mysteries of many new and unknown compounds.

PROTEIN RECOVERED

From Still Waste by Use of Waste Lignin

ADDITION of small amounts of lignin from the waste liquor of sulfite pulp manufacture to the waste from alcohol stills operating on grain, precipitates most of the protein in convenient form to filter, according to a recently published research report of the Overly Biochemical Research Foundation.

Distillers have always had trouble disposing of their wastes largely because they contain proteins. But proteins are also valuable foodstuffs. The present technique provides an inexpensive way to remove the valuable proteins from the stillage slops. In a sense it is a case of "setting a thief to catch a thief," since both stillage waste and sulfite liquor are noxious substances, difficult to dispose of. Addition of lignin to the stillage waste causes the protein to precipitate out in an easily handled form for recovery. Not only is food value conserved but pollution of streams by the wastes is prevented.

USEFUL GLYCOLS

Are Bases of Many Drugs and Cosmetics

AN UNUSUAL family of chemicals are the higher polyethylene glycols, with uses ranging from shoe polish to hair dressings, and from medicinals to glazing of china. They are both unctuous and water-soluble, a combination of properties never before available in single compounds, C. P. McClelland and R. L. Bateman explain in a report to the American Chemical Society.

These products are commercially available now in four liquid and five waxlike solid forms, the latter known as Carbowax, and have broad uses in many different industries.

Each is actually a mixture of several polymers and each represents a band of molecular weights. Their properties vary with molecular weights. The melting points, flash points, specific gravity, viscosity, and aqueous solubilizing actions all increase with increasing molecular weight, while water solubility, vapor pressure, hygroscopicity, and solubility in organic solvents generally decrease with increasing molecular weight.

Hair dressings, hand lotions, suntan creams, leg lotions, and skin, powder base, and shaving creams have all been made by leading cosmetic manufacturers from these glycols. A number of specialty creams, including ink removers, are also based on them.

The use of these compounds in pharmaceutical ointments has developed rapidly and shows promise of becoming even larger. Sulfanilamide and sulfathiazole are both soluble in the higher polyethylene glycols. Sulfadiazine and sulfapyridine are less so. Thus, unctuous bases such as Carbowax compound 1500 serve as ointment vehicles for these drugs, while the harder polymers, Carbowax compounds 4000 and 6000, function as dusting vehicles for them.

Cathodic Protection

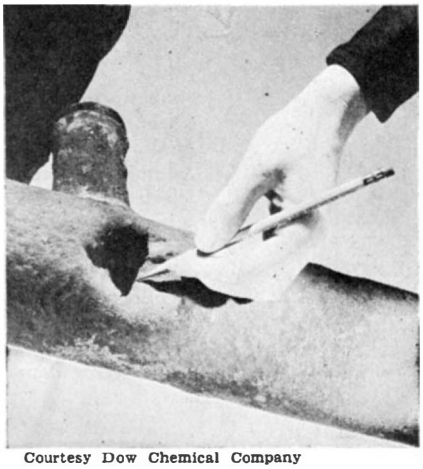
Pipelines and Other Underground Metallic Structures are Constantly Subject to Corrosion Caused by Galvanic Currents. Control of Such Corrosion Can be Obtained by the Use of Buried Anodes Which Set Up Counter Potentials. Masses of Magnesium Offer a Ready Solution

By L. H. WOODMAN

MAGNESIUM, the versatile light metal which, after a quarter century of obscurity, bloomed suddenly into wartime prominence and now holds promise of changing many of our established concepts of tomorrow through the reduction of useless weight, is becoming, strangely enough, an ally of steel pipe.

A simple cylinder of the metal, four inches in diameter and 16 inches or more in length, may be the key to saving the nation's consumers of gas, oil, and water millions of dollars annually in costs of replacing and repairing corroded underground pipelines. The results of laboratory research and field tests carried on by The Dow Chemical Company indicate that the use of these magnesium cylinders in cathodic protection of underground pipelines will be an effective and economical procedure and will at the same time offer a substantial market for secondary (reclaimed scrap) as well as primary magnesium.

Gas, oil, and utility companies operate hundreds of thousands of miles of buried pipelines, totaling more than double the combined mileage of all railroads in the United States, and this tremendous network is undergoing constant expansion. While a variety of protective coatings are employed to retard corrosion of these vital and costly lines, pinholes and breaks in such coatings occurring during the laying of the line appear to be inevitable. The method of cathodic protection has been found most effective not only in arresting and preventing corrosion through these pinholes and breaks but also in preventing corrosion of bare pipe.

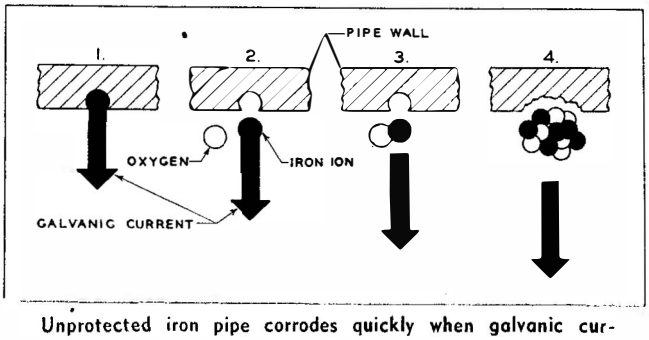


Courtesy Dow Chemical Company

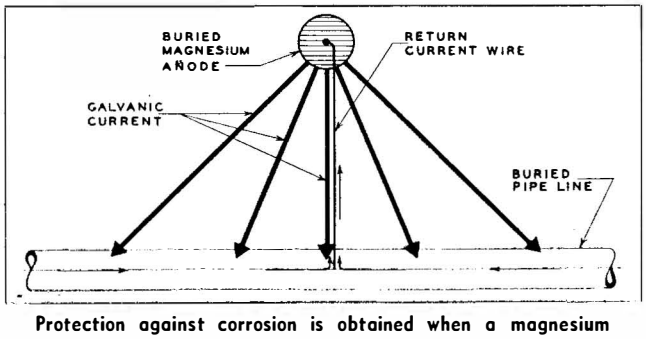
A typical example of a corrosion break occurring at an "anode area" of a steel pipe. The ends of this four-foot length were essentially unharmed

Corrosion of underground metal tanks, foundations, pipelines, and similar structures is engendered chiefly by galvanic electrical currents. Such currents are set up by impurities in the metal, soil variations, and numerous other causes impossible to predict or to control effectively. In this action the corroding areas of the metal assume the characteristics of electrical anodes, the current passing through the moist soil to other areas of the metal which act as cathodes. As the current leaves the surface of an anodic area of the metal it carries with it iron ions which combine with oxygen to form iron oxide. As this action continues a pit is formed which gradually becomes deeper and eventually, in the case of a pipeline or tank, results in leakage as in the example illustrated at the left.

OUTSIDE CURRENTS—It has long been recognized that if these currents could be prevented from leaving the surface of the metal, such corrosion could be prevented. Thus was developed the system of cathodic protection, which involves changing the anodic areas of the buried metal to cathodes by introducing from an outside source a current stronger than the potential in the metal being protected. This idea was first em-



Unprotected iron pipe corrodes quickly when galvanic currents, set up by various causes, carry with them iron ions which combine with oxygen in the soil to form iron oxide



Protection against corrosion is obtained when a magnesium anode sets up galvanic currents which flow into the pipe and oppose the outflowing currents that cause corrosion

ployed by Sir Humphrey Davy in 1823 for preserving the copper sheathing on ships, but only in recent years has the principle been applied to buried metallic structures. Conventional procedure has been to employ an anode of carbon or a bed of scrap-iron buried near the structure to be protected and connected to the positive side of some source of direct current. A return wire connects the protected structure with the negative side of the power source. Thus current is caused to flow *into* the metal through the soil. The potential of this current is sufficient to overcome the potential of outward currents of the galvanic action, thereby eliminating the cause of corrosion.

This method obviously entails some source of power. Where alternating current lines are available, rectifiers may be used. Where no such facilities are at hand, wind-driven or engine-driven generators are commonly employed. However, since extensive pipelines require a series of anodes placed at intervals along the line, this method necessarily involves rather complex and costly electrical installations.

SELF-GENERATED POTENTIALS — A more simple and economical form of cathodic protection, therefore, involves the use of an anode made of some material having in itself a higher potential than the metal to be protected, which will thereby set up its own current by galvanic action without the necessity of an outside source of power. It is this principle which is employed to advantage by using magnesium anodes.

Zinc anodes have been employed in the same manner. They give a driving voltage against iron of 0.4 to 0.5 volts which is generally sufficient to afford protection. Zinc, however, tends to polarize gradually, thus giving less and less protection as time goes on. Because of this factor the degree of protection at any given time after installation of zinc anodes is problematical, polarization not taking place at a constant rate. While zinc of very high purity has shown little tendency to polarize, its use increases the cost of the anodes considerably.

The work done by Dow now shows that anodes of certain alloys of magnesium have a driving voltage against iron of approximately 1.0 volt, or roughly twice that of zinc, that they show no polarization, and that these alloys can be readily and economically cast from either scrap or primary magnesium. While the connecting wires must be welded to the pipe to be protected, the anodes themselves may be put down with a post hole digger or such other convenient means as soil conditions may dictate. Skilled electricians are not required as in the case of the outside power installations and the actual costs of the magnesium anode installation are relatively low.

ALL UNDERGROUND — Another factor in favor of both zinc and magnesium anodes is that there need be no equipment, or even wires, above ground to invite vandalism. That this seemingly insignificant point can be a matter of real importance is illustrated by the wryly amusing story told of a firm having extensive pipelines running through a remote section of South America. Wind-driven generators, employed with scrap-iron cathodes, kept disappearing and replacement was becoming a substantial cost item when the company's engineer discovered that members of the native tribes simply did not "rate" unless they had one of those "windmills" to decorate the front of their hut.

Magnesium anodes have been cast principally in 14-pound cylinders with six-foot lengths of wire cast into one end for making the connection to the pipe. Such factors as depth of installation, distance from

Courtesy Dow Chemical Company
Cast magnesium anodes

pipe and spacing along the line are dependent upon soil conditions, protective coating of pipe, and many other variable factors which must be determined in each case by corrosion engineers. The service life of a given mass of magnesium is likewise governed greatly by soil conditions, and it appears likely that anodes eventually will be cast in a variety of weights so that the corrosion engineer will be able to obtain sizes calculated to give, for example, two years, or five years, or perhaps ten years of service under known soil conditions. Various shapes and core arrangements are also under investigation. The 14-pound cylinder might be said to have a service life of approximately four years under "average" soil conditions, although corrosion engineers will hasten to declare that there is no such thing as an "average" soil.

CORROSION LOSS

Rated as 2 Percent Annually of Iron and Steel

APPROXIMATELY 2 percent of the total weight of iron and steel in use in this country is lost annually due to corrosion and must be replaced, according to Dr. Hugh McDonald, director of the corrosion laboratory recently established at Illinois Institute of Technology. "That percentage is an important item in war time. Through research we are attempting to cut the loss."

The only educational and research center stressing corrosion in the United States, the laboratory will carry on a basic, long-range research program on the fundamental theory of the mechanism of corrosion processes and control, and will serve as a center for graduate instruction in the science and engineering problems of corrosion.

Dr. McDonald adds that the problem will become of even greater importance in the post-war period when thousands of tons of intricately-built equipment will be stored in government warehouses for periods of from 30 days to perhaps 20 years.

POWER TRAINS

Generate Electricity Needed At Fighting Fronts

MOBILE electric power trains are one answer to pushing back the enemy and "setting up shop" in the midst of blown-up power plants. By the use of railroad cars of special design mounted on standard trucks, tanks, trucks, and other war equipment can be repaired close to the front. The idea, an American one, has been a god-send to the Russians.

This portable power comes in the form of a train of 10 railroad cars easily transported to devastated areas to provide power and light within a few hours. Specially designed steam boilers are being made for mobile power units at The Baldwin Locomotive Works. The boilers are shipped to the American Car and Foundry plant, where they are mounted on cars with other apparatus supplied by General Electric and its subcontractors and shipped as an assembled power train.

Each power train consists of two boilers, two tenders carrying coal and water, one car containing auxiliary equipment, another containing the main turbine, generator, and surface condenser, and three cars containing equipment to cool condenser water. In actual operation a tenth car is added to serve as crew quarters.

These mobile power plants on their own wheels are hauled by railroads to the site, spotted on a single track and need only the connection of steam pipes, water pipes, and electric cables, all carried on the cars, to be ready for operation.

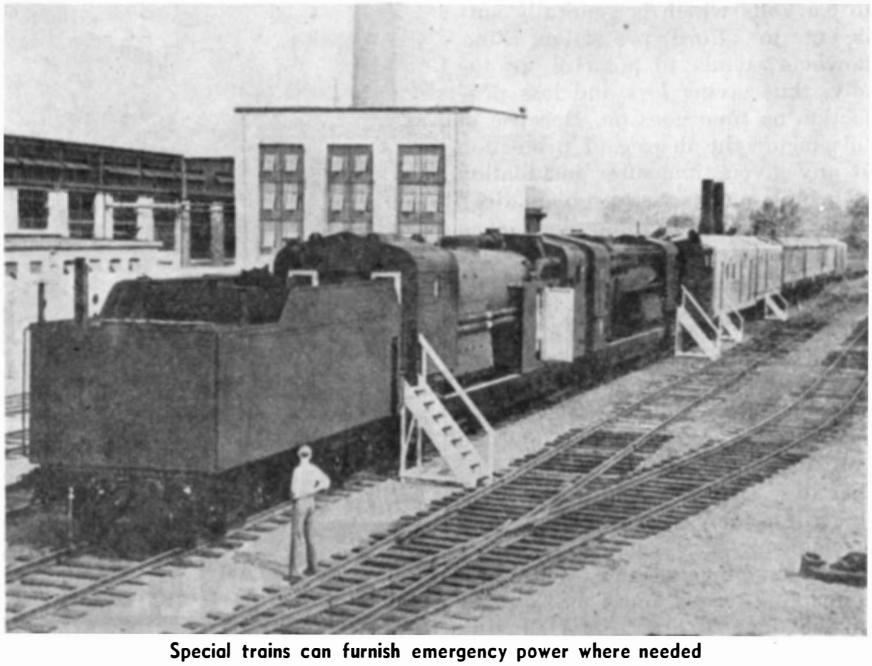
The power train is designed for a continuous output of 3000 kilowatts, using coal having a heating value of less than 7000 B.t.u. per pound. This heating value is much lower than that of the poorest grade of coal obtainable in the United States.

COLOR CONDITIONING

Of Industrial Interiors Brings Higher Production

FUNCTIONAL color for industrial interiors to improve employee efficiency, health, and comfort will be a post-war reality. Described as the science of determining the correct industrial color environment for maximum vision, the system has been developed by Du Pont in collaboration with Faber Birren, leading industrial color authority. Among the benefits of "color conditioning" are listed increased production, improved quality of workmanship, and reduced personal injuries.

The technique is designed to protect employees against eyestrain by reducing glare and eliminating extreme contrasts between light and dark. It recommends restraint in us-



Special trains can furnish emergency power where needed

ing color, especially distracting, over-stimulating hues, as well as abolishing light-robbing and dangerous dark areas.

Research findings have determined correct colors for factory walls, for machines, and for backgrounds within the field of vision. Surveys of entire plants where an integrated color system has been put in effect from front to rear door demonstrate that uniform wall, dado, and equipment painting, with a "change of pace" for corridors, stair wells, and washrooms, yield beneficial results as revealed in comparative safety, production, and absentee records. Only a few colors in combinations need be utilized, the studies show.

New colors have been developed for industrial interiors. These are not decorator's colors in the bright, clear range, but hues subdued in tone and unobtrusive and practical. In selecting the colors, illuminating and color engineers studied light-reflectance qualities, hue characteristics, influence of different kinds of illumination, and psychological characteristics.

PLANE ENGINES

Will Be Carefully Chosen To Give Greatest Safety

EXTREME care in the selection of aircraft engines to fill specific needs in post-war operations will be required by new standards of service and safety in commercial air line operations, according to Charles Froesch, chief engineer of Eastern Air Lines.

"While the air transport operator," says Mr. Froesch, "is reconciled to the thought that the conventional type of reciprocating internal combustion engine will be used for several years more, he is, nevertheless, following the development of the gas turbine with interest. Its simplicity and relative ease of installation are tempting characteristics, but its low thermal efficiency, as reflected by high specific fuel consumption, is at present a serious disadvantage. This will undoubtedly be overcome by the development of materials which can stand higher operating temperature, but with them may come greater difficulties of thermal nature, which engineers have been trying to remedy in the present type of engines.

"Transport aircraft designed before the war," Mr. Froesch continues, "as a result of air-line operating experiences with the Douglas DC-3's for many years, were put in mass production during the present conflict and utilized far more than was anticipated. These aircraft have been operated with loads and at speeds which were not thought to be safely possible. Operational characteristics have been developed and experimental testing of newer equipment indicates that we have grown technically to a point where our pre-war thinking must be adjusted."

Mr. Froesch goes on to say that there is general agreement that two engines are the minimum requirement for flight safety, since the carriers will be flying in more difficult weather than heretofore. Size of the engine selected depends to a large degree on the total number of engines used and the type of operation for which a plane is designed, he adds, noting that under Civil Aeronautics regulations twin-engine planes are required to develop higher total take-off power than planes equipped with four-engine power-plants.

GOOD FROM WAR

Seen by Scientist In Optical Appliances

SEVEN WAR-TIME optical inventions which have important post-war applications are cited by Dr. E. D. Tillyer, research director of the American Optical Company, as concrete evidence that some good has come out of the tragedy of war. The inventions, he says, were developed

to fill certain military needs and are now aiding the war effort. They include:

1. A new method of reducing light reflections, useful in removing annoying or dangerous glare from auto windshields, shop windows and cases, paintings, photographs, and instrument and camera lenses. 2. New charts for testing color blindness, which makes the United States independent of Germany and Japan, previous sources for such charts. 3. New types of sun glasses and goggles which provide maximum eye comfort outdoors by absorbing annoying glare and invisible rays. 4. A new all-plastics artificial eye which rivals a human eye in color and appearance, resists breakage and corrosion, and can be re-shaped to fit the eye socket precisely and therefore comfortably. 5. A new absorptive welding glass which permits gas welders to look through blinding glare and see welding operations, thus speeding production and protecting eyes. 6. A new glass which offers resistance to hydrofluoric acid which disintegrates ordinary glass. It is useful for safety lenses and laboratory glassware. 7. A new process of annealing or heat-treating optical glass, which stabilizes the glass and makes possible improved types of lenses.

ALL-WELDED HOSPITAL

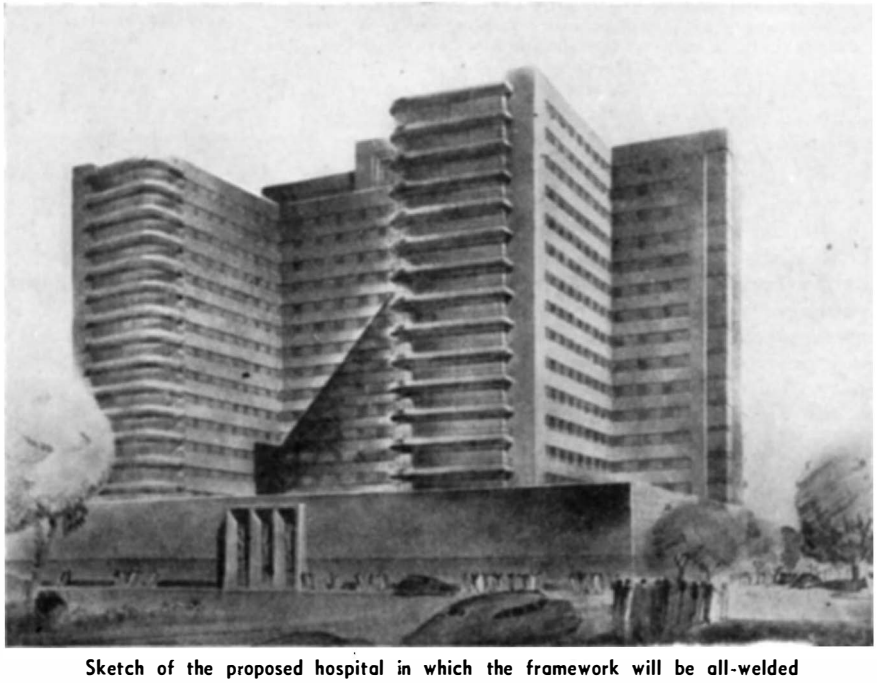
Will be Erected When Materials Are Available

PRELIMINARY details have been worked out for what is believed to be the first all-welded hospital building in the country. The 18-story structure embodies the most progressive ideas in modern design and furnishes a significant clue to the general type of building construction that can be expected as soon as restrictions on material are lifted.

It is proposed that the framework of the new unit, to be known as Kahler Hospital, will be designed as a continuous structure of beams and their connecting members, welding details of which are based on past analysis and conform to general engineering acceptance.

In preparing the specifications, the architects, according to the Lincoln Electric Company, discarded all concepts of riveted construction, which tends to restrict the range of application of certain welding details.

The hospital building, to be erected at Rochester, Minnesota, will cover an area of 150 feet by 270 feet, or about half a city block, and will be built of welded steel with concrete floor slabs.



Sketch of the proposed hospital in which the framework will be all-welded

WEATHER MACHINE

Creates Rain and Sunlight To Test Materials

KNOWN as a weather-ometer, a new machine provides conditions equivalent to sunlight at noon in June, and a water spray of varying intensity to simulate rain. It allows the effects of sunlight, periodic rain, and temperature changes on a material under test to be determined in advance.

Light and water spray periods are automatically controlled. Interchangeable nozzles determine the volume of water delivered, with the material under test controlling which shall be used. One of the automatic controls allows the light to remain on for the test period and drenches the material with water for three minutes every 17 minutes. Other controls permit interruption of the light and starting of the water spray at intervals.

Inserting a test sample of material in the new "weather-making" machine

One of the major tasks of the machine as used by B. F. Goodrich is to evaluate the weathering ability of Koroseal to see that it measures up to specifications.

ACTIVATED CARBON

Has Extended Surface For Chemical Absorption

A CHEMICAL cousin of both diamond and coke, activated carbon is a powerful tool of many increasing uses, ranging from life-saving service in gas masks to salvage of a host of valuable materials. A smooth, solid, one-inch cube of chalk has a surface of six square inches, but "the same weight of the best activated carbon possesses an available surface of 59,400 square yards or about 12 acres," Drs. Ernst Berl and Walter G. Berl of the Carnegie Institute of Technology explain in summarizing research in this field.

Activated carbons can be tailor-made to fit various needs, and the large, pitted, and porous surface "is a powerful tool for the adsorption, elimination, or recovery of a host of desirable and undesirable substances.

"Most war and industrial poisons in concentrations that would be immediately fatal if inhaled are filtered out completely in less than 1/100 second contact.

"Valuable solvent vapors, as ether and alcohol in the production of rayon or smokeless powder, which are carried off by air during the drying operation, are completely recovered on passing through beds of activated carbon. They can be separated and revived by extraction with live steam. Similarly, valuable liquid gasoline fractions in natural gas or benzene in coke oven gas can be separated conveniently."

(*Continued from page* 39)

especially close control during the melting and pouring operations, with induction heating equipment virtually essential.

A very recent development holding much promise for the production of Alnico magnets of larger size and greater intricacy is the use of the precision ("lost wax") casting method for making such magnets. This overcomes the machinability limitation by permitting the direct casting of the magnets to very close dimensional tolerances and with satisfactory magnetic properties.

Thus we see modern methods—powder metallurgy, induction melting, precision casting—coming to the aid of a new material whose potentialities could not otherwise have been fully utilized because of normal processing limitations. We may confidently expect continued improvement in permanent magnet materials and a steady expansion in their overall use in electrical and electronic equipment.

CORROSION PROTECTION

Afforded to Steel by Silver Cladding

ADD TO the modern clad metals with bright possibilities for the future silver-clad steel used in chemical and petroleum industry equipment that will handle hydrofluoric acid in high octane gas production and also resists chlorinated solvents. Silver-*clad* steel is superior, it is said, to silver-*lined* steel because the former has better heat conductivity.

INDUCTION HEATING

Has Great Advantages In Metal Forging

LARGE-SCALE application of the induction method to forging-heating has shown a particularly rapid trend during the war. Because induction heating is at its best in high-production applications, it was the obvious selection for a large part of the war-born forging capacity of the nation. This trend was accelerated both by the lack of skilled forge-plant help and by the opportunity to build new plants and install new forging capacity without having to write-off existing facilities.

A recent survey of operating conditions has turned up some interesting data. For example, induction heating produces virtually no scale, while furnace heating produces scale amounting to as much as 6 percent of the total weight of the heated piece; the elimination of scale not only saves metal but often extends die life 300 to 400 percent.

Again, heating times are very rapid: A 1⅜-inch diameter steel bar comes up to 2300, Fahrenheit, in eight seconds and a 3-inch diameter bar in two minutes, by induction heating, whereas much longer time would be required by ordinary methods.

When heating bar stock larger than ¾-inch in diameter it is possible to use the lower frequencies produced by motor-generator sets rather than spark-gap or electronic oscillators. Bars larger than two inches can be economically heated for forging only with frequencies as low as 960 cycles per second.

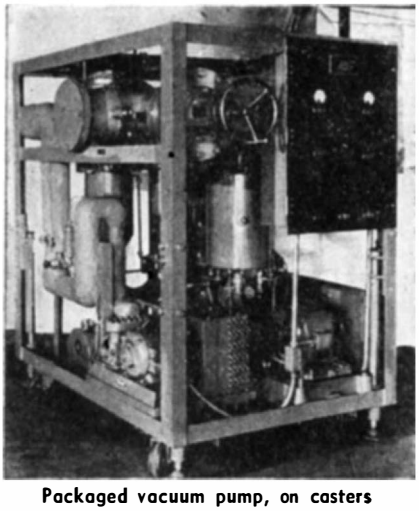
An interesting point is that, although the electrical efficiency of heating nonferrous metals inductively is less than that for steel, the power requirements to heat to forging temperatures are no higher for the nonferrous metals—simply because the nonferrous metals have lower forging temperatures; they do not have to be raised to as high temperatures as steel.

New Products and Processes

VACUUM PUMP

In Compact Unit, Easy to Use

COMPLETE high-vacuum pumping systems, in new compact units for direct connection to the vacuum lines to be evacuated, are now available in various capacities. Each consists of a mechanical forepump, diffusion pump, high vacuum valves, gages, and control panel. Mechanically refrigerated traps are built in on special order.



Packaged vacuum pump, on casters

These unit systems are simple to operate and eliminate the necessity of setting up complicated high vacuum pumping systems. Only one connection is necessary. The unit is fully automatic and incorporates various safety and protective features. Vacuum conditions are indicated continuously on the control panel, and recorders may be used.

Development of these "package-type" vacuum-producing units is credited to the Vacuum Engineering Division of National Research Corporation.

GIANT LENS

May be Used in Aerial Map-Making

A PHOTOGRAPHIC lens with a built-in heating system has been designed for the Air Forces and soon may be produced by the Eastman Kodak Company. The lens is a 48-inch monster for aerial photography, and the thermostatically controlled electrical warming device in the mount will operate when the lens is used in the cold upper regions. Without it, the metal of the lens mount would shrink enough at low temperatures to throw the lens out of focus.

By interlapping successive "shots" taken at heights of eight miles or more with the new lens, 9-by-18-inch pictures can be made into a giant-size map of a countryside that will reveal detail far more clearly than pictures previously taken at the same altitude. When used with infra-red film, the new lens is expected to aid greatly in the detection of camouflage. Its use with color film will help to point up obscure detail.

DOUBLE FLARING

Made Easy with New Machine

A DOUBLE flaring or lapping machine, developed at the request of aircraft manufacturers, is expected to have wide application in industry. It produces a double thickness of metal on flanges or flares, thereby enabling the tube to hold a much greater working pressure and to have greater resistance to failure at the connection.

Manufactured under the trade name of Tube Master by the Leonard Precision Products Company, the machine is simple in operation and requires little skill. No hand tools are necessary.

To change the size of dies, the operator unscrews the face plate and inserts the proper size dies. The tool bar slides out of the head for change of punches. While the machine is intended for nonferrous tubing sizes ⅛ inch to ½ inch, special dies can be furnished to handle annealed ferrous tubing, sizes ⅛ inch to ⅜ inch. Model DF, now available, is entirely pneumatic in operation, requiring an average of 100 pounds air line pressure.

PLASTICS COATINGS

Preserve Wine Flavor, Prevent Corrosion

PLASTICS protective coating may be responsible for a natural taste in wine and brandy which otherwise might acquire cloudiness and metallic flavors from storage in bare steel or concrete vats. Other coatings of the same plastics family keep aviation gasoline, stored in concrete tanks, similarly free of contamination, while still others protect the outer parts of steel ships from the action of sun, wind, and wave. In the same way, the steel water control gates of giant canals are preserved from the destroying effects of the acids and minerals in the water and alternate wetting and drying in the hot sun.

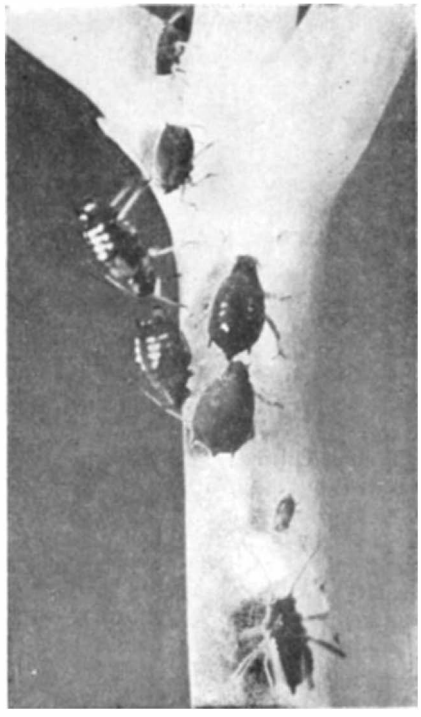
Producers of wine and brandy were among the first to discover that "Vinylite" plastics coating, developed by American Pipe and Construction Company, would prevent contamination by iron or calcium salts from the steel or concrete of the tanks in which they were made and stored. These same resins have alleviated, if not removed, the corrosion and contamination problems of the fuel and fish storage tanks of tuna clippers. These tanks are alternately filled with fuel oil on the trip out to the fishing grounds and with refrigerated salt brine and fish on the way back. The combination of alternating exposure to fuel oil, salt brine, fish oils, and freezing temperatures, and the abrasion caused by the rubbing of the fish, is a severe test for any protective coating.

Aviation gasoline will seep through all except the most impermeable materials; but, even more important, if aviation gasoline remains in contact with alkaline concrete for long periods of time, such as when it is being transported in concrete ships, it will become unstable because of the reaction of its stabilizer with concrete. Steel boot-topping strips on fast liners are about ten feet wide and extend around the hull at the water line. The steel is thus exposed at different times to sun, wind, waves, and physical abrasion. The plastics coatings that protect this critical area similarly protect the steel of the water-controlled gates on the Gila and All-American canals in Arizona and the Imperial Valley in California, among others.

INSECTICIDE

Made Synthetically For Garden Use

A POWERFUL synthetic insect-killer promises this season to meet United States vegetable growers' urgent need for an insecticide to replace the war-scarce rotenone, pyrethrum, and nicotine sulfate used to control aphids,



Sucking insects, such as these black bean aphids, are reported to be controlled by a new synthetic insecticide

afhoppers, and other insect pests. nown as Lethane B-71, it has under- ne four years of extensive field test- ig on tomato, pea, bean, spinach, and abbage crops by large growers and tate Experiment Stations. For the ntrol of sucking insects on these sential crops, the chemical has dem- nstrated a killing power equal to nico- ne, rotenone, and pyrethrum.

Vegetable growers who have de- ended on these imported materials to rotect their crops from sucking in- cts—those which draw juice from the lant and are killed only by a power- ul contact poison—are welcoming the nthetic toxicant developed by the ohm and Haas Company.

OTTLE WATCHER

Automatically Rejects Those With Flaws

A DECIDED benefit to food processors nd consumers alike is seen in the de- elopment of a photoelectric crack de- ector that inspects glass jars and ottles as they pass on a rotary turn- able, automatically singling out and jecting those that contain minute racks or surface irregularities. Such aws, if they were to pass unnoticed, ight prevent airtight sealing and re- ult in spoilage of the contents.

This crack detector is more accurate an a human inspector in uncovering efects in glass containers and is much ore rapid. Inspecting bottles as fast s they are made on a bottle-making achine, which may be one or more very second, it detects flaws barely isible to the naked eye. General lectric, in collaboration with the artford-Empire Company, developed ie machine especially for use in food ackaging plants. In one such plant it as previously found that, on the verage, two out of every 100 glass ontainers with flaws escaped detection y human inspectors.

In operation the detector rejects ulty containers without interrupting ie continuous bottle making process. s the containers automatically move front of a sensitive photoelectric ibe, they are whirled rapidly while a rong light is directed on the part to e inspected. Since the phototube is ot affected by a steady light, the light eflected by a perfect glass produces o effect. A rapidly spinning bottle ith even the slightest imperfection n the sealing edge, however, causes ie light beam to flicker, and this uick change in the intensity of the eam is sufficient to eject the imperfect ontainer while the perfect ones are lowed to continue on their way.

AFETY CLOTHING

Standards Improved to Protect Workers

ASBESTOS clothing fabricated accord- g to new American war standard ecifications will lessen the menace radiant heat and molten metal lashes for steel mill and foundry orkers. These standards cover as- estos aprons, cape sleeves and bibs, leggings and coats—garments that are used widely in industry to provide insulation against extreme heat during the course of the day's work, and protection against sudden splashes or spills of molten metal that may mean painful "lost time" burns or even death. Whether splashed asbestos coats, leggings, or sleeves will scorch slowly enough to give their wearers time to get out of danger and remove the garment and whether the smoldering garments can be quickly shed are of vital importance.

For these reasons, the quality of the asbestos and the design of the garment were chief considerations of the subcommittee of the American Standards Association that drew up the new standards. Only second in importance, however, was the need to conserve scarce materials depleted by wartime demands.

Among the problems that confronted the committee was the fact that few scientific tests for wearing or fire-resistive qualities of varying grades of asbestos had been made, and the fact that nearly all available cloth was needed by the armed Forces, making it necessary to use efficiently what asbestos cloth there was. Scientific data on which to base these standards was obtained with the aid of the National Bureau of Standards which carried out tests for the fire-resistive quality of varying grades of asbestos cloth.

Altogether, there are four separate standards. The first one covers the widely used bib type asbestos aprons. Only plain and split-leg types of apron are included in this standard since, in the opinion of the committee, these will service industry adequately. In addition to the minimum requirements for the material—weave, yarn ply, thread count, grade of asbestos, weight of cloth, and breaking strength—methods of test for the asbestos content, water of composition, weight of the asbestos cloth, and breaking strength of the cloth are included. When leather is used in reinforcing the asbestos garments, tests are specified for grease content, chromic oxide, acidity, heat resistance and shrinkage, and thickness

of the leather. A corrosion test for hardware, such as metal fasteners for the aprons is included.

Specifications for cape sleeves to protect arms, shoulders, neck, and upper chest are outlined in the second standard. These include plain cape sleeves. Different sizes for men and women are listed. Sleeves are designed to reduce the bulkiness of the asbestos at the fold of the arm. The shape of the garment is specified, as well as seams, stitching and edges, rivets, and hardware.

The standard for knee and hip-length leggings in men's and women's sizes gives specifications for wrap-around and spring types in both knee and hip-length leggings, and in the pull-on type for hip-length leggings. The method of fastening is specified to facilitate removal. The coat standard provides one type of asbestos coat in hip, knee, and ankle lengths. Because asbestos, unlike leather, comes in regular widths, not more than three pieces of asbestos may be used in the coat, exclusive of the sleeves and collar, and not more than two of these pieces may be used for the entire front. Thus the back of the asbestos coat must be made in one piece, whereas in the case of leather coats more than one piece may be used in the back only, to permit maximum use of the material.

50-GALLON SHAKER

Saves Time and Labor in Mixing Automotive Paints

SPECIAL equipment is being used these days to speed production, lighten tasks, and insure the output of uniform paints for the automotive industry. Two such devices, mechanical shakers for 50-gallon drums and five-gallon cans, were developed especially at the request of the Ford Motor Company.

The idea of churning paint in a 50-gallon drum came shortly after a gallon mechanical shaker was purchased for use in a company laboratory to mix paint samples. Previously, paint stirring was a long and tedious task. Paint was shipped in five-gallon cans and 50-gallon drums equipped with stirrers packed separately. In addition to the labor en-

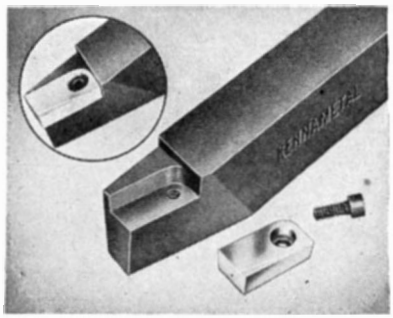
Paint mixer handles 50-gallon drum

tailed, there also was the possibility of paint leakage from the openings through which stirrers were inserted. When the gallon shaker proved feasible, it was decided to try a five-gallon machine. After the larger unit proved successful, a shaker was constructed to handle a 50-gallon drum. By means of this device, a drum of enamel can be mixed in about two hours.

TOOL BLANKS

Are Drilled for Attachment To Steel Shank

A TOOL blank has been developed having a drilled and counterbored hole to provide for attachment to a steel shank by means of a recessed-head cap screw. The angularly-set screw serves merely to hold the tip against the re-



Recessed walls resist thrusts

cess walls, which resist the main cutting thrusts.

These blanks are now available in several of the larger sizes, with formed clearance angles and in all standard grades of Kennametal which is also the name of the manufacturer. Complete tools of various styles—straight edge, lead angle, offset, and so on—can now be furnished with the screwed-on tips. Separate standard blanks will be supplied to those who wish to make their own tools. Blanks of non-standard shapes and sizes having this feature may also be had for special tools, such as are used in shell turning and form cutting of radii and grooves.

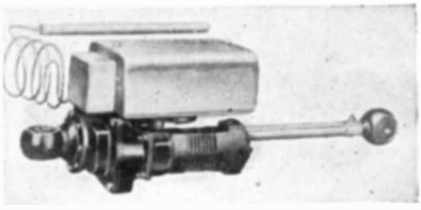
LINEAR ACTUATORS

Light in Weight, Take Little Power

WEIGHING as little as 3.05 pounds, linear actuators have been built to meet the increasing demand of the aviation industry for an efficient method of converting electrical energy into linear actuating force. The design engineer will find them applicable in many places in post-war products.

The Lear Model "400" actuators are made to operate under loads up to 400 pounds of compression or tension. They require low power, 24-28 volts, and have extremely low current drain on the electrical system. In size, the "400" model is less than five inches wide and less than seven inches long, including the limit switch control box and the thermal protector. The extension length ranges from 14⅞ inches to almost 25 inches. These actuators provide a complete package inasmuch as the unit provides the desired moving force without the need of additional accessories.

Exact positioning under all conditions is an outstanding advantage, and



Actuator with temperature control unit

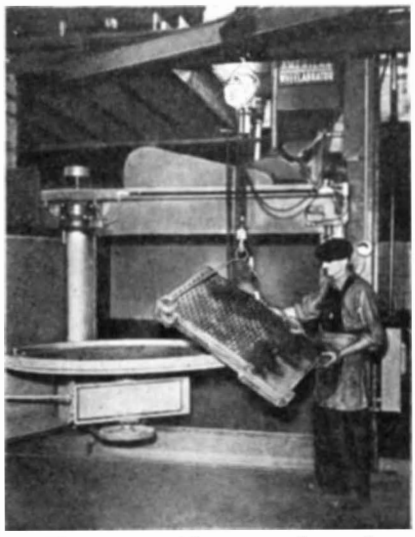
control boxes are equipped with limit switch control of two or three or more positions. Incorporation of the Lear "Fastop" clutch eliminates any overtravel. A movement of a few thousandths of an inch disengages the driven disk of the clutch from the driving disk which is secured to the armature shaft. Gear reduction ratios are available in various combinations. Position-indicating transmitters for visual check are also available.

BLAST CLEANING

Use Extended by Rotary Swing Tables

AIRLESS blast cleaning is being extended to a wide range of intricate or irregular shaped work, formerly cleaned in air-blast rooms, by the use of Wheelabrator Swing Table units manufactured in four sizes by American Foundry Equipment Company. Operation of the four units is essentially the same, the machines varying only in table size and in minor construction details.

Work to be cleaned is placed upon a rubber-covered work table which is



The rotary table carries the work

mounted on the door of the blast cabinet. As the door is closed, the work table swings into the cabinet underneath a Wheelabrator airless blast unit. While in this position the table is rotated at a predetermined speed. The unit whips a continuous stream of abrasive down upon the rotating work to the full width of the table so that

all surfaces are uniformly blasted to a bright, clean finish. Only a short exposure of the parts to the Wheelabrator unit is required to clean the exposed surfaces thoroughly and uniformly. The unit is then stopped, the door is swung open and the part is turned over for cleaning the underside.

After striking the work, the abrasive falls through perforations in the table top into a hopper below the machine. A screw conveyor transfers the abrasive to the elevator which carries it to an overhead abrasive separator. All broken-down abrasive and useless fines are removed and the usable abrasive falls into a storage hopper for reuse.

PACKAGED COAL

Blocks Made from Waste Will Lessen Fuel Shortage

WRAPPED in paper by a new packaging machine as part of a Government sponsored idea to help alleviate the fuel shortage, coal block packages, each weighing 7½ pounds, are made up of hitherto wasted anthracite and bituminous fines. The wrapping machine, made by the Package Machinery Company, turns them out at the rate of 8 to 24 per minute.

The first such machine is already in operation in the Blaw-Knox test plant. Endorsed by the Solid Fuels Administration, the coal blocks, so clean that they can literally be handled with white gloves, will be marketed to householders for furnaces, fire places, cook stoves, and water heaters.

FILTER CLEANER

Diluted with Water, Cleans All Types

DEVELOPMENT of a new process for chemical cleaning of all types of air filters, including air conditioning, engine, marine, and aircraft, has been achieved by Turco Products, Inc. The process eliminates the necessity of using distillate and other materials which leave an offensive odor and are a fire hazard. It also greatly shortens the time required for the complete operation. Under the new process, the filter is removed and immersed for only six minutes in a tank of cold Turco Aktiv, four ounces to a gallon of water. The filter is then removed from the tank and given a cold water hosing to flush away dirt and grease; then dried in a stream of compressed air and dipped into the manufacturer's specified oil. According to time studies, the entire process takes under 13 minutes.

Dipping cleans all air filters

PORTABLE PUMP

Helps to Extinguish Industrial Fires

A NEW light-weight and compact centrifugal pump has many industrial uses including fire fighting and evacuating water from flooded manholes, basements, drainage ditches, and the like. For small factories and mills erected at a distance from city water mains,

Multi-use pump on a trailer

the Rex Speed Prime pump is extremely valuable in the event of fire. Larger plants whose buildings cover considerable areas have mounted these pumps on two-wheel trailers, along with other fire-fighting equipment for speedy towing to the scenes of sudden outbreaks of fire. When used for this purpose, the pumps are altered to accommodate regulation fire hose.

HERMETIC SEALING

Applied to Instruments With Moving Parts

DEVELOPMENT of a method for hermetically sealing electric instruments against humidity, water, dust, fungus, discoloration, and other adverse conditions, was announced recently by engineers of the General Electric Company's meter and instrument laboratory. In tests these instruments have been submerged in 60 feet of water for several days, have been suddenly transferred from a temperature of 67 degrees below zero to one of 185 degrees above, and subjected to dust storms, all without causing any change in their performance.

Experience has shown that in certain climates, especially in the tropics, instruments became corroded, their molded parts swelled and burst, fungus covered the sensitive springs, and, in some cases, the pointers on the instruments fell off. In developing a means for overcoming these conditions, General Electric produced the first hermetical sealing of an instrument containing a moving part.

To obtain a hermetically sealed en-

closure, a thick, strain-free glass window is fused to a metal ring in a glass-to-metal seal. This assembly is then fused to a steel case by a soldered joint. Hermetic sealing of the two terminal studs is obtained by glass-to-metal seals between each metal stud and the metal eyelet. This hermetic assembly is sealed to the steel base by a silver-solder operation.

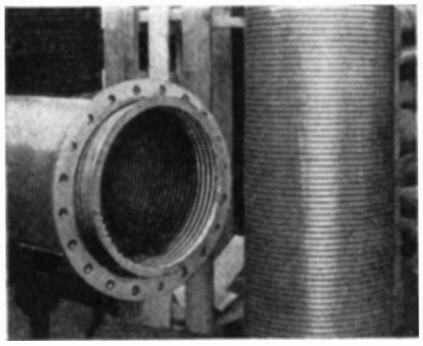
The metal base is secured to the case by means of a synthetic-rubber gasket that is coated with a special sealing compound. The seal is obtained by a crimped-over metal ring, which compresses and retains the gasket.

The glass seal, the soldered joints, and the metal ring form a completely hermetic enclosure for the instrument. According to laboratory tests, this means of sealing is unaffected by thermal shock, mechanical shock, or vibration. The final assembly is evacuated, filled with an inert gas through a seal-off tube located in the base, and is sealed off at a pressure slightly above atmospheric.

METALLIC HOSE

Is Asbestos-Packed For Diesel Exhaust

AN ASBESTOS packed interlocked galvanized steel hose, with an inside diameter of 24 inches, weighs approxi-



Flexible steel exhaust pipes

mately 70 pounds per foot and is manufactured for use on marine and stationary Diesels as flexible exhaust pipes. Because of its interlocked construction it requires no special tools or heat to bend. This new hose, manufactured by Pennsylvania Flexible Metallic Tubing Company, has a recommended bending radius of approximately seven times its diameter and a working pressure of 15 to 25 pounds per square inch.

WIRING KIT

Provided with Versatile Installation Tool

NOW AVAILABLE to industry for general solderless wiring is a complete electrical wiring kit that includes a six-purpose precision installation tool which cuts and strips the wire, indicates stud sizes, and crimps terminals to the wire. The kit also has an assortment of 100 solderless terminals of the most commonly used types. No soldering is required to make trouble-free

For solderless electric terminals

electrical connections; it is necessary only to insert wire in terminal barrel and crimp with tool. The kit is made by the Aircraft-Marine Products, Inc.

ENGINE DETECTOR

Indicates Impending Trouble in Advance

MULTI-ENGINED airplane pilots can now tell in advance whether they are going to encounter engine trouble, thanks to a new-type instrument developed by research engineers of Consolidated Vultee Aircraft Corporation.

Technically, the instrument is known as an "engine performance indicator." It comprises a rectangular metal box full of electrical equipment, small enough to fit in the side coat pocket of a man's suit. It is installed adjacent to the carburetor of an airplane engine, and its function is to measure the distance (right or left) to which the engine is displaced when the propeller is rotating.

If the engine is functioning normally, the instrument actuates a gage in the pilot's compartment; and this gage shows, with greater accuracy than any similar device previously developed, how much horsepower the engine is putting out. Then, if the engine begins to operate improperly the gage needle oscillates accordingly and a warning light glows on the pilot's instrument panel—giving the pilot plenty of time to cut the engine and feather the propeller.

Previously, because there were no suitable engine warning devices, pilots often could not detect power plant

troubles before an engine actually failed; and then, sometimes, it was too late. Most multi-engined airplanes can fly safely with half of their engines inoperative; but accidents have occurred because the pilots could not detect trouble quickly enough to adjust engine controls and feather propellers. The latter items are important due to the fact that a malfunctioning engine can tear itself to pieces or catch fire, while a "windmilling" propeller will create excessive drag forces and make an airplane difficult to control.

SIDE HANDLE DRILL

Encased in Light and Durable Plastics

A NEW development of Thor plastics encased portable electric drills introduces a side handle type machine which is 20 percent lighter than comparably rated drills with aluminum

Handle position offers advantages

casings, according to the manufacturers, the Independent Pneumatic Tool Company.

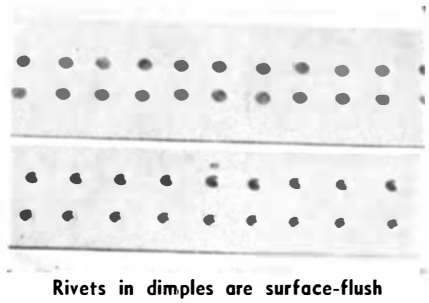
The new side handle drills are identical in construction with the original plastics encased pistol grip unit, except for the handle. The gear case, field case, and handle are molded in a specially developed plastics while all internal operating parts are supported in a metal frame entirely separate of the plastics housings—an independent unit so constructed that the tool will operate perfectly with all housings detached.

ALUMINUM DIMPLING

By New Method Saves Time and Expense

A SUCCESSFUL method for dimpling high-strength, heat-treated aluminum alloys in all thicknesses up to and including .081 inch has been developed by the Ryan Aeronautical Company. This new method utilizes a tool which fits the standard dimpling machine. The procedure is simple, inexpensive, rapid, and easily taught to the operator. It produces strong, well-formed dimples in high-strength aluminum alloys without radial or circumferential fractures.

The success of the process is due to the fact that the metal is formed in such a manner that the stresses are distributed over a wider area, elimi-



Rivets in dimples are surface-flush

nating stress concentrations and their consequent fractures.

The dimple, being a cone-shaped depression around the rivet hole, is a requisite for the use of flush-type rivets. These rivets are used in joining the exterior metal sheets of airplanes because their flat, flush-type heads contribute to the aerodynamic smoothness of the plane, by reducing drag, and because they are lighter in weight. In order to allow the rivet to recess flush with the surface of the skin, a dimple must be formed around the rivet hole. This dimple should have the same angle as the rivet and should nest around the rivet head in close contact with all of its contiguous area

CENTER SCOPE

Designed to be Used In Precision Shop Work

BUILT to withstand ordinary shop usage, a new optical locating and centering microscope is molded of gray Tenite plastic. It is designed to locate or center edges, lines, or punch marks on a workpiece to the spindle axis of any machine tool. It is also used for measuring dimensions which are inaccessible to mechanical devices and for checking and inspection work.

Optical lighting is not subject to errors such as pressure, wear, temperature, and human variations. With the center scope, accurate work may be produced in a minimum amount of time.

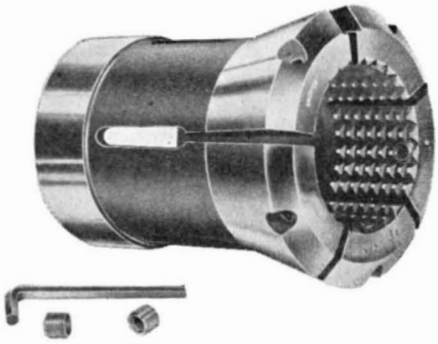
Optical locating and centering scope

The new center scope is injection-molded of Tenite in four pieces. Since the walls are rather thick and vary in thickness, close tolerances are held throughout, and care is taken to prevent shrinkages which might interfere with the precision of the instrument. The plastics is molded over two metal parts: the shank which fits into a drill chuck or collet; the tube at the bottom which guides and supports the objective lens mount. The eye piece and end piece are pressed into place and cannot work loose or slip.

NEW COLLETS

Have Strong Grip, Long Life

INCORPORATING in each serrated section a "cup-point" lug which penetrates the stock slightly when locked, a new collet is now being manufactured. The lugs are usually set .010 to .015 inches above regular serrations but can be adjusted for more or less penetration, or can be turned away completely, leaving only the standard serrations effective. These adjustments can be made without removing the collet from the machine. With additional holding power, less locking tension is required to hold the lock firmly, which tends to longer life of machine mechanisms as well as collet. "Super Grip" collets, made by the Sheffer Collet Company, are particularly effective for handling hot-rolled steel and on jobs where heavy tool thrusts cause slippage through conventional serrated jaws.



Adjustable lugs add holding power

CLEANING TISSUE

Made Specifically for Optical Surfaces

A LENS cleaning tissue recently introduced to the industrial and technical fields is a soft, silky linen tissue, specially prepared for cleaning fine optical and precision mechanical instruments. The tissues are processed for tensile strength and absorption qualities, and under all types of rigid tests have cleaned optical surfaces and precision parts without scratching or leaving the slightest trace of lint, regardless of the amount of cleaning and rubbing done. A product of the Superfine Lens Cleaner Company, these tissues are available in 10-inch rolls, 500 feet long, and in other convenient sizes.

Current Bulletin Briefs

Conducted by K. M. CANAVAN

(The Editor will appreciate it if you will mention Scientific American when writing for any of the publications listed below.)

LUBRICATION OF INDUSTRIAL MACHINERY is a 58-page thoroughly illustrated brochure which deals with the fundamentals of lubrication, types of bearings, selection of lubricants, methods of applying lubricants, and maintenance problems. The main part of the booklet is generalized: an appendix deals with a number of specific machine lubrication systems. Request Technical Bulletin Number B-5. *Sun Oil Company, Industrial Products Department, Philadelphia, Pennsylvania.—Gratis.*

HOW AND WHY CATHODE RAY TUBES WORK is a 16-page booklet based on the history, mathematical concepts, manufacturing problems, testing, and design of C-R tubes. Complete television set-ups are discussed. *North American Philips Company, Inc., 100 East 42nd Street, New York 17, N. Y. —Gratis.*

RUST, CAUSES AND PREVENTION, is a 74-page booklet, eminently practical in its content, which deals not only with metal corrosion but also tells how metal surfaces can be conditioned before application of preventive measures. It then deals in adequate detail with the preventive methods themselves and with the metals used. *E. F. Houghton and Company, 303 West Lehigh Avenue, Philadelphia 33, Pennsylvania.—Available to manufacturing executives if requested on business letterheads.*

POST-WAR PLANNING FOR INDUSTRY, PART V: SMALL BUSINESS—NOW AND AFTER THE WAR is one of a series of bulletins giving references to, and abstracts of, sources of information on the problems of small business, government aids, and research facilities for small business. *Business Information Bureau, Cleveland Public Library, Cleveland 14, Ohio.—Gratis.*

OPPORTUNITIES IN RADIO AND ELECTRONICS FOR RETURNING SERVICE MEN, by Brigadier General David Sarnoff, is a 28-page booklet designed to aid war veterans in applying their war-time training and experience to development of careers in civilian life. The text covers the entire scope briefly and is supplemented by a complete bibliography of suggested reading. *Radio Corporation of America, 30 Rockefeller Plaza, New York 20, New York.—Gratis.*

SCREW THREAD INSERTS AND THE SCREW THREAD SYSTEM is a four-page bulletin describing Heli-Coil inserts and the Aero-Thread screw thread system.

It includes engineering data, typical applications, and a statement of the advantages of each design. *Aircraft Screw Products Company, Inc., 47-23 35th Street, Long Island City 1, New York. —Gratis.*

POST-GRADUATE COURSE FOR GEARS is a 20-page booklet compiled as a suggestion course for designers of new products using right-angle reduction gearing. Current war-time uses of Cone-Drive are outlined as a guide to possible current and future uses. *Michigan Tool Company, Cone-Drive Division, 7171 East McNichols Road, Detroit 12, Michigan.—Gratis.*

BYERS WROUGHT IRON FOR RADIANT HEATING is a 52-page handbook whose chief purpose is to serve as a working manual in calculating, designing, and installing radiant heating systems. Answers are given to the 34 questions most frequently asked. *A. M. Byers Company, Pittsburgh, Pennsylvania.—Gratis.*

ELECTRICAL TEST INSTRUMENTS is a bulletin outlining the inherent accuracy and reliability of accepted laboratory circuits and techniques reduced to simplest terms for lay operation in everyday industry. *Industrial Instruments, Inc., 17 Pollock Avenue. Jersey City, New Jersey.—Gratis.*

NATURAL AND SYNTHETIC RUBBER ADHESIVES is a 12-page booklet presenting information on how to choose the right kind of cement for various applications. The booklet contains a table giving data on cement weights, colors, and base materials used as well as an outline of the differences between vulcanizing and non-vulcanizing types of rubber cement. *B. F. Goodrich, Public Relations Department, Akron, Ohio.—Gratis.*

FLEXIBLE SHAFT REMOTE VALVE OPERATING GEAR is a 31-page booklet including the most advanced engineering information relating to valve-control practice suitable for industrial, chemical, and marine use. *Stow Manufacturing Company, Binghamton, New York.—Gratis.*

ELECTRIC TIMERS, BULLETIN NUMBER 1100, is a four-page circular outlining various industrial and laboratory testing applications of table and wall model stop clocks, precision chronoscopes, stop watch controllers, and spring wound X-ray timers. *C. H. Stoelting Company, Industrial Division, 424-P North Homan Avenue, Chicago 24, Illinois.—Gratis.*

POLYWELD, THE CHOICE OF RADIO MEN, is a six-page bulletin dealing with liquid polystyrene—its dielectric constant and power loss factor. It is recommended for "doping," coating, impregnating, or sealing for radio frequency, ultra-high frequency, very-high frequency, or general electronic applications. *American Phenolic Corporation, 1830 South 54th Avenue, Chicago 50, Illinois.—Gratis to electronic engineers, radio men, and radio amateurs.*

Our Book Corner

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THE MODERN GAS TURBINE

By R. Tom Sawyer

OF IMMENSE interest today to the technical man and the ordinary citizen, the gas turbine has been discussed at great length in the last few years in the newspapers and the magazines. Now a highly qualified authority has written this comprehensive textbook. The fundamental treatment which he gives the subject will be welcomed by many who want a source of accurate and thorough knowledge of this engineering development that holds promise of being widely adapted in industry and transportation in the years following the war. In addition to covering industrial, marine, railroad, and turbo-supercharger applications of the gas turbine, Mr. Sawyer includes up-to-the-minute data on its application in aviation's latest and most interesting development—jet propulsion. This book is undoubtedly one of the most important contributions so far made to the literature of the gas turbine. It will be widely read, and it deserves to be. (216 pages, 6 by 9½ inches, many illustrations, index.)—$4.10 postpaid.—*J.C.*

INDUSTRIAL PURCHASING

By Edwin Laird Cady

TEAM work in industry is essential to successful operation; one of the most important men on the industrial team is the purchasing agent. He is in a position to further the interests of his employer out of all proportion to the importance—or rather lack of importance—which too many people attach to his job. In this book, Mr. Cady, one of the Contributing Editors to Scientific American, digs deeply into the functions of the successful purchasing agent and shows particularly how this job can best be coördinated with the rest of the team. The text will serve not only to put many a purchasing agent on the right track but will interest everyone who has any contact with purchasing. Sales managers, production executives, salesmen, and accountants will find much meat in this book which has been written out of years of contact with industrial management. Because of the simplicity with which its practical lessons are handled, it will also provide a comprehensive view of industry for those youngsters who have ahead of them the job of finding out what makes the world of business tick. Without a doubt this is the most searching analysis of the whole broad field of industrial purchasing that has ever been made available in straightforward, down to earth, factual style. (256 pages, 6 by 9 inches, a few reproductions of printed forms, comprehensive index.)—$2.85 postpaid. —*A.P.P.*

FOR THE SAKE OF ARGUMENT

By Norman G. Shidle

EDITORIALS—19 of them—from the *Journal of the Society of Automotive Engineers* comprise the text of this interesting little book. They give the answers of an experienced editor in the field of industrial journalism to the question: What is chiefly responsible for fits and misfits, successes and failures in this competitive economy of ours? It makes extremely stimulating reading because the reader will undoubtedly conduct many a mental argument with the author. (32 pages, 6 by 9½ inches, unillustrated, paper covers.)—$1.00 postpaid.—*A.P.P.*

TELESCOPES AND ACCESSORIES

By Dimitroff and Baker

FINAL book of the Harvard-Books-on-Astronomy series. Contents: Light as a Tool (optical basics); Visual Telescopes (types of objectives and eyepieces); Storing Light (the photographic process, with discussion of fine-grain developers, emulsions); Photographic Telescopes (image errors; highly curved types of photographic reflectors — Schwarzchild, Couder, Ritchey-Chretien, Schmidt, Wright, Maksutov, Baker, Petzval, Cooke triplet, Ross lens—with flexible, unit-focus curve specifications for the optics of each); Sifting Light (spectroscopy); Measuring Light (pho-

tometry); Instruments for Solar Research (spectroheliograph, spectrohelioscope, McMath-Hulbert Observatory, coronagraph, quartz monochrometer); Building a Telescope (general discussion, with recognition of amateurs); Invisible Glass (evaporated films); Lists of largest telescopes and of Schmidt cameras (amateur and professional); striking photographs of diffraction images. This book is compact, tells much in few—perhaps too few—words. Suitable for advanced amateurs. (309 pages, 5¾ by 8½ inches, 182 illustrations.)—$2.60 postpaid.—*A.G.I.*

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Edited by John D. Ratcliff

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Edited by Francis E. McMurtrie

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By Bowen C. Dees, Professor of Physics, Mississippi College

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By Waldemar Kaempffert

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By Ysabel F. Rennie

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By Edward L. Bernays

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THE BUILDERS OF THE BRIDGE

By D. B. Steinman

HERE is the story of two great engineers, John Roebling and his son, Washington, whose work was an immense contribution to the advancement of America in the last century. The sucessful bridge-building career of John Roebling, an immigrant from Germany, culminated in his plan for the Brooklyn Bridge, most graceful of suspension structures. But just as the arduous task was getting under way, Roebling received a foot injury that caused his death. The bridge was completed by his son, Washington, a gifted engineer, a brave soldier in the Civil War, and a man carved from the same granite as his father. This book is his story, too. The author has brought to his task of biography a deep and understanding admiration for those two great Americans. (457 pages, 5½ by 8¼ inches, index, illustrations.)—$3.60 postpaid.—*J.C.*

Telescoptics

A Monthly Department for the Amateur Telescope Maker

Conducted by ALBERT G. INGALLS

Editor of the Scientific American books "Amateur Telescope Making" and "Amateur Telescope Making—Advanced"

IN THE fourth edition of "Amateur Telescope Making," in his chapter on the design of mountings for telescopes, Porter wrote (page 142) that he knew of nothing better for a stable polar axis than the crankshaft of an auto engine, together with the engine block itself. Several telescopes have subsequently been made, using such axes.

Before going into Army service, Daniel Langpaap, 200 Kessing Ave., Porterville, California, sent in a description of a 6" reflector (Figure 1) mounted in that manner. He states that the engine unit cost 75 cents and the whole telescope, including mirror kit and aluminizing of the finished mirror, $16.81.

"The hour circle is graduated on the flywheel, and the declination circle is a protractor. Parts of the starter assembly are used as the slow motion."

Commenting on Figure 1, R. W. Porter says, "I've never seen a mounting that showed so much strength and weakness. If Langpaap would stiffen his slender fork with struts to the flywheel, this would altogether alter its stability." When shown this comment Langpaap replied, "The Army was on my tail and I wanted to get the job done before I was inducted and they didn't leave me time to do that. This is my first telescope, but it isn't going to be my last. I am now in the army (aged 18), so this ends my telescope making for the duration.

"I think," he adds "there is too much warning the beginner about the difficulties of mirror making. My mirror came out an oblate spheroid but figuring this to a paraboloid took only half an hour."

By all odds the most blood-curdling warning to the beginner has been Ellison's paragraph at the opening of Chapter V in "Amateur Telescope Making," where he ominously says: "We now come to the crux of the whole process. Grinding and polishing are purely mechanical processes, which any handy man should be capable of learning in a few lessons. But the man who can produce a perfectly true paraboloidal curve right up to the edge of a mirror is not a mechanic, but an artist; and the artist is born, not made." He continues: "Volumes might be written on the art of figuring and the reader of them would be no nearer being able to produce a true curve after reading them than before, if the talent were not born in him."

Figure 1: Engine block mounting

Something has now been done about these awesome sentences. From time to time, as stocks of "A.T.M." are sold out, new printings are made and, while a new printing is not a new edition, minor textual changes may be made on these occasions. One change that has just been made for the current

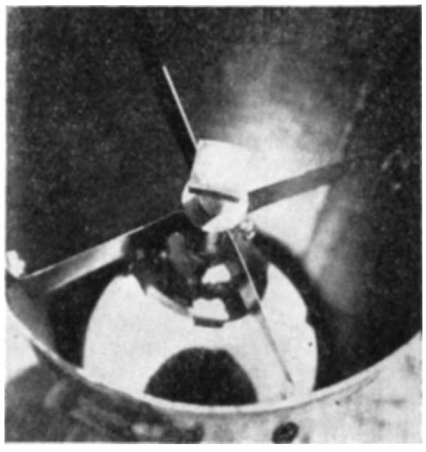

Figure 2: Big diagonal: diffraction

fifth printing of the fourth edition is the insertion, on page 95, of the following Editor's Note, directly bearing on Ellison's bogey.

"Many old-timers, advanced amateurs, vividly recalling the misgivings caused when they were novices by the opening paragraph of the above chapter, have urged with feeling that it be struck out of the book. It also must have discouraged many from even starting.

"It is probable that many—perhaps most—novices run away with the belief that a telescope either has a perfect mirror or it will not perform. At the risk of seeming to encourage slovenly standards it ought to be explained by the Society for the Prevention of Cruelty to Beginners that a mirror has to be pretty bad before it won't perform; also that a mediocre mirror will usually seem, at least for some time till your observing acuity has been educated, to be about as nearly perfect as your first grandchild; and that the reasonably good mirror you should aim to make on your first try will probably seem about perfect for a while. Thus Ellison's paragraph misleads beginners by omission.

"Many, before beginning, think of making one telescope and one mirror,

Figure 3: Angel cake catch-pan

which must of course be tops or else, and thereafter using it indefinitely. More common is something like this: On trying out your first mirror you exclaim, 'I did better than I thought I could.' After a few weeks you add, 'but I know its faults and can do better, and while I'm at it I'll make a bigger telescope.' A year or so later you build a third, again larger, and your third mirror will be on nodding terms with Ellison's described ideal. All along, as your observing eye has become more exacting, your manual skill has improved to keep pace. (About this time you go back and, out of curiosity, re-test your first mirrors—the ones you once thought good—and maybe grin a little.)

"As for 'talent,' Ellison doesn't specify how much talent is needed but everybody has talent, which is mainly perspiration. The words 'artist . . . born, not made' have been a real bogey to some, but read Ellison closely; he applies those terms to perfect mirrors alone.

"All sorts of plain average folks, thousands of them, have made successful mirrors, even editors. Cheer up."

Experienced amateurs who recall the howling of the banshee in their dreams after their first reading of Ellison's paragraph, quoted above, may now perhaps feel satisfied that this specter can no longer make the tyro's hair stand on end.

"While home on a furlough," writes another Army man, Pfc. James B. Downs, Jr., 14164282, Co. N, 847th Signal Training Battalion, Camp Crowder, Missouri, "I got into a discussion with an Atlanta amateur telescope maker. As always, the discussion arrived at 'A.T.M.,' 'A.T.M.A.,' and your column 'Telescoptics.' We remembered somewhere you had mentioned that you expected an average of one or two mirrors per copy of 'A.T.M.' Our little club in Atlanta, appropriately called 'The Cloudy Night Observers,' has in its possession copies of 'A.T.M.' and 'A.T.M.A.' that have 13 mirrors to their credit and one in process.

"The books belong to C. B. Moore, Jr., who broke them in on a 6" *f*/8, a 6" *f*/3.5, and an 8" *f*/10. From him, the books went to D. E. Bowers and myself, where the following were ground: 4" *f*/16, 4" *f*/8, 4" *f*/3.6, 4" *f*/1.5, 6" *f*/2, and an 8" *f*/6.3. [Note wide focal ratio spread of the four 4" mirrors: excellent experience for the worker who would put himself through the mill.—*Ed.*]

"The 6" *f*/2 turned out better than was expected. It necessitated the use of an extremely large diagonal (Figure 2) which cuts its effective light-gathering power very much [and adds to diffraction.—*Ed.*]. Nevertheless, the 12" focal length and 6" diameter is very useful for nebular observing. Some of the very faintest nebulae show up. The power is low but the field is very wide.

"Figure 3 shows the 6" *f*/2 in the pre-polishing stage, using levigated alumina [and, as a most useful catch-pan, an angel cake tin exactly like one your scribe uses.—*Ed.*]. We carried the pre-polishing until the glass

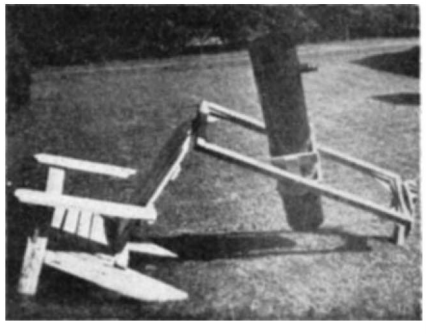

Figure 4: Simple portable mounting

was almost polished before changing to rouge. The total time for rouge and levigated alumina was about two thirds of the time rouge alone would have required.

"It is amazing what a sturdy portable mounting (Figure 4) can be made from some 2 x 2's, 2 x 4's, a dozen nails and a common lawn chair.

"From us 'A.T.M.' and 'A.T.M.A.' next went to C. H. Kitchens and John Brown who built a 6" *f*/3.8, an 8" *f*/9, and a 3" *f*/4.4. The 3" is pocket sized and Brown is carrying it with him in the Army. The books then went to Conrad Meaders, who ground a 6" *f*/8. Then they went to Rolf Sinclair.

"Thus for two books we have 13 completed mirrors and one more in process."

INTERMITTENT mirror makers, who can work a week but then must go away for a month, often return to find their pitch laps in bad shape because of slow flow and filling in of channels. N. J. Siegel, Box 116, Forest Hills, N. Y., obviates this difficulty by suspending the lap, face down, over water in a receptacle. This keeps it moist and cool.

What Siegel actually does is to make the lap on a round metal plate much larger than the mirror, and uses a cardboard collar to confine the melted pitch to the desired diameter. Then, when leaving it for a protracted period, he inverts it over the water, the metal plate tightly sealing the receptacle at the same time. Since the lap is made on the flat backing, rather than the curved one of the usual glass tool, the pitch is thicker at the center. When suspended upside down it therefore tends to flow downward more at the center and this, he says, is easier to cold-press back.

To dispose of the mirror while absent he submerges it, face up, in the same receptacle and marks it "Don't Touch." In some households this is probably sufficient but in others, where the lady with the grim, determined face, the eager eye, and the waving dust mop goes on a tidying-up binge once a week, a burglar-proof safe, large enough to take the whole kit, is recommended. Mysterious "spooks" often scratch mirrors. One such finally proved to be the Everest's cat. Roaming the cellar o' nights it tracked across coarse Carbo on the floor and then tramped over the mirrors left between working sessions.

CARBORUNDUM grains are obtainable two series, the familiar numbered series, like Nos. 80, 120, 220, 400, 600, and a lettered series, F, FF, FFF. Many workers have been puzzled about the reason for the two partly overlapping series and the relation between them. Here is the answer, from the manufacturers.

The approximate numerical grading of the F series is F: 280; FF: 320; FFF: 500.

The numerical powders are more closely graded.

SOME thermal expansion coefficients per degree centigrade.

Common glass, about	0.0000090
Quartz glass	0.00000058
Pyrex	0.0000032
Pyrex telescope disks	0.0000033
200" mirror	0.0000024

IN "A.T.M." are innumberable sidelights that are likely to be missed unless the worker "chinks in" between mirror-making spells by frequent restudy. Here is a case in point, in which a worker had read a certain note but it had not registered in his mind until he happened to read it while he was wrestling with a certain mirror problem on which it bore.

"Not long ago I recall saying 'I wish I could get hold of a mirror with a perfect edge, in order to know exactly what I am supposed to shoot at.' Not long after that my eyes fell on Hindle's paragraph on page 371, 'A.T.M.' For the first time I realized what it meant. Eyes that don't see! Here was the very thing I had been hunting. It took only a few seconds to cut a mask concealing the edge of the mirror, and the diffraction ring which appeared around the inner edge of the mask was evenly illuminated on both sides, just as both edges of Everest's straight-edge ('A.T.M.' page 371) are illuminated. On removing the mask I was able to see that my right edge was brighter than the left, and so my edge was not perfect. I set to work, and finally brought it right. When I had done all that seemed possible, I found that the edge looked the same with the mask as without it."

Printed in the U. S. A. Press of the Wilson H. Lee Company, Orange, Connecticut.

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