Scientific American

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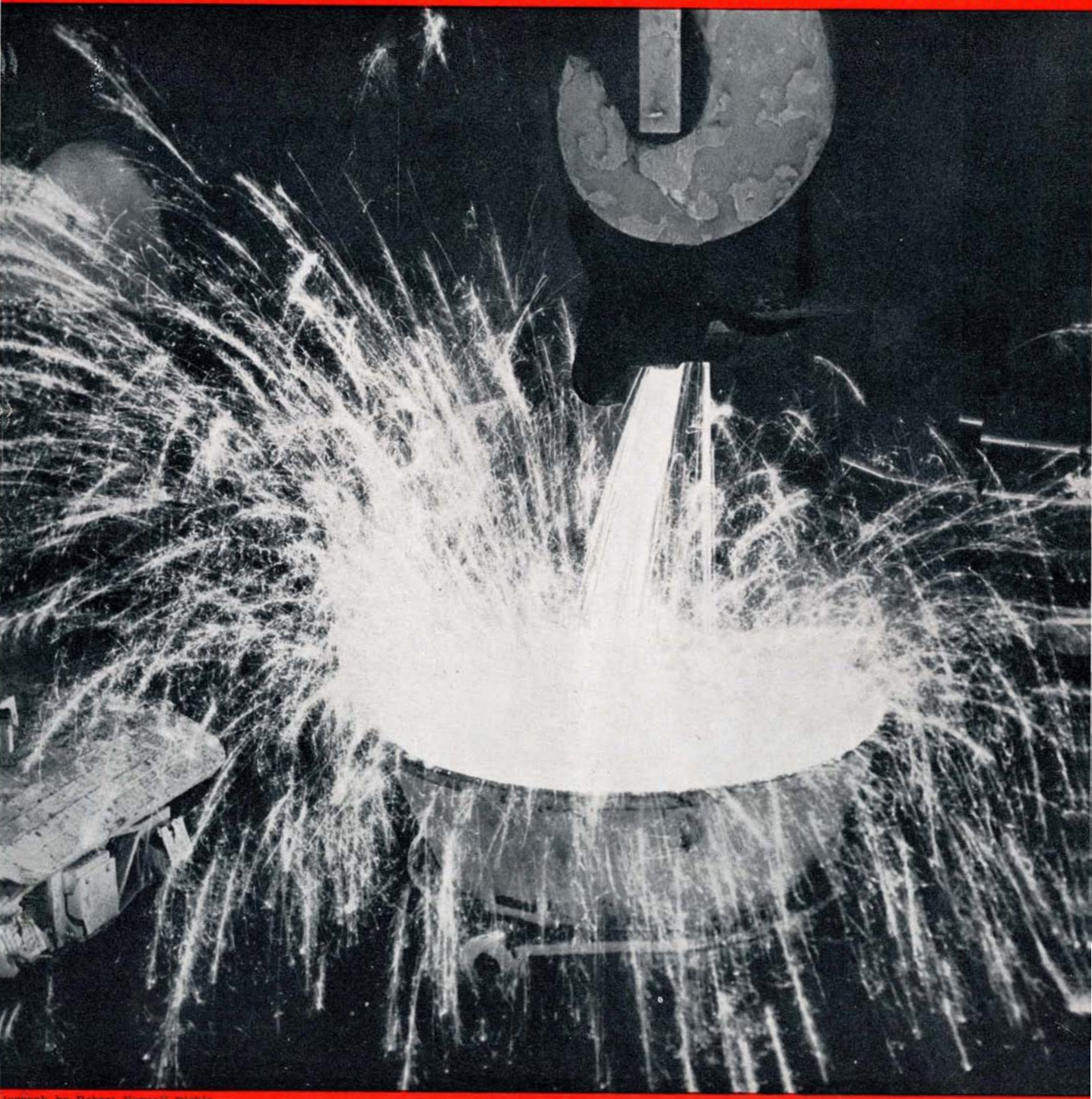

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Foundry Progress . . . See pages 98 and 115

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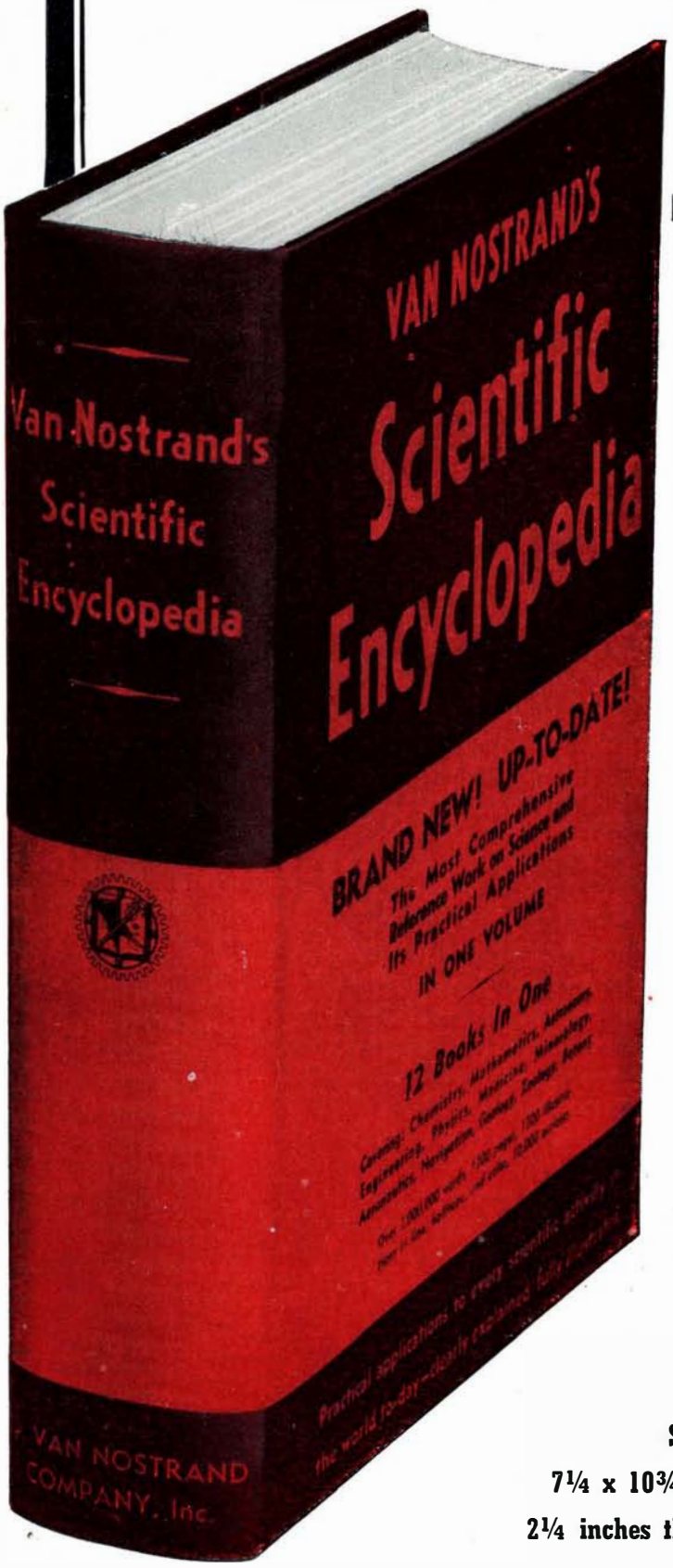

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CONTENTS • MARCH 1944

COVER: Dramatic is the scene in a foundry when slag remaining in the bottom of the "bull" ladle is dumped into the cinder bucket after the steel has been poured. Equally dramatic, and far more important to our industrial world, is the story of technological progress that is being made in all branches of the foundry industry. For details see the article starting on page 115 of this issue.

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Previews of the Industrial Horizon

By A. P. Peck

WOOD IN THE FUTURE

EVIDENCE that the wood industry—mildly castigated in the item on paper published on this page in our January issue—is doing something about the problems of perpetuating their raw material source, is to be found in information which has just come to hand.

For years Scientific American has advocated forest conservation. Trees are living, growing things which constitute our only regenerating natural heritage. Once coal or oil are removed from the ground, they cannot be replaced. But if forests are scientifically managed—intelligently harvested and replenished by adequate replanting programs—they can continue indefinitely to serve the needs of mankind.

What is needed, then, is continuing active work on the part of the wood industry as a whole to provide the means whereby new growth of wood will annually equal or exceed the amount harvested. An estimate made in 1920 placed wood growth at six billion cubic feet a year; an equally reliable estimate made in 1936 (the last year for which figures are available) indicated an increase to over 11 billion cubic feet of growth, or only 20 percent less than the total amount of wood harvested that year plus the losses due to fire, insects, and disease.

Here is definite encouragement that the gap between wood use and wood growth is closing. Reserves still dwindle, but the rate of dwindling is slackening. For the long pull this is significant, since industry is constantly finding new uses for wood. As the chemical industry calls for more and more wood to use as a basic raw material, as paper products increase in applications, as construction work puts into active use the recent developments in wood fabrication, the demand for wood will increase beyond anything ever dreamed of in the past.

Thus, when scientific management of forests hits its full stride, and there is every indication that it will do so in the not too far distant future, industrial America will be assured of a continuing supply of this needed material.

FAIR AND COOLER

NOT all the technological advances now held in abeyance, so far as the ultimate consumer is concerned, are traceable directly to the war effort. A case in point is the unit room cooler and air conditioner, for summer comfort and for treatment of some respiratory ailments, which was just beginning to come into its own in 1941. Estimates for post-war production of these units range from 100,000 to 200,000 per year, but The Crosley Corporation, always optimistic about the right product at the right price, foresees sales of such units soaring to the mark of a million annually.

Certain it is that room coolers offer decided advantages of comfort and better working conditions; equally certain is the fact that recent improvements in materials and know-how can be applied to production of units superior to those made in 1941. Post-war potential market for such coolers will undoubtedly be large. Whether the million a year mark will be reached depends upon the ingenuity of industry.

RADIO ON THE RAILROAD

FOR many years sporadic experiments have been conducted with radio communication between fixed stations and moving trains. Radio receivers have become standard equipment, for entertainment purposes, on many trains. Other applications of this form of communication to railroad work have been toyed with and then dropped.

Now, however, there is a spot on the horizon that, from this distance, appears to presage the use of standardized radio equipment on railroads for routine dispatching purposes. Undoubtedly such usage would supplement wire dispatching, the block system, and other railroad safety installations. But radio would go farther than anything now used. It would tend, by providing a continuously operating means of communication with train crews, to reduce greatly the possibility of disasters of the type that have been occurring all too frequently on American railroads in the past few months.

CHEMICALS FROM GAS

LOOK upon natural gas as a raw material source for the chemical industry in the near future. Virtually a chemical twin to petroleum, natural gas is currently being used to the extent of over 95 percent of production for industrial and household fuel. It is entirely probable, however, that more and more of this gas will be diverted to other purposes.

Butadiene, glycerine, carbon tetrachloride, gasoline, sulfa drugs, and fertilizers are some of the products available directly or indirectly from natural gas. Upon such possibilities can technology build an important chemical future for this product of nature.

PNEUMATIC DISPOSAL OF REFUSE

SEEMINGLY fantastic propositions, when backed by the solid judgement of qualified technicians, deserve studied thought before dismissal. Thus when sanitary engineer Morris M. Cohn, of Schenectady, New York, proposes that the refuse of cities of the future be disposed of through intricate systems of pneumatic tubes, the idea should not be dismissed too abruptly as impractical.

Garbage, ashes, and household refuse of all kinds would be handled by the tube systems, equipped with air-lock chambers at each point of entry and powered by strategically located booster stations to maintain adequate suction.

Such a system, as Mr. Cohn says, would require a "complete re-orientation of engineering ideas." It would also provide a huge market for construction materials and labor.

UNIT HEATERS

RELIABLE report has it that there has been developed for the United States Army a portable, self-contained and self-powered forced warm-air furnace that weighs only 45 pounds and is about the size of an average suitcase. Although details are still under the well-known cloak of military secrecy, it is apparent that this furnace will circulate enough warmed air to meet the needs of the average family home during even very cold weather.

Here, it appears, is a possible logical answer to many home-heating problems, from the complexity of the conventional heating system to the high cost of fuel.

TIN TOMORROW

PROBABLY the worst-squeezed of all the metals during the war emergency has been tin. As a result of substitution necessities, many other products have been developed to replace tin in various uses, often with advantages not offered by the shiny metal. Here is something that tin is going to have to overcome in the post-war world and to this end the tin industry is already planning a campaign of research and information dissemination. This is going to be an interesting development to watch and one which promises results.

50 Years Ago in . . .

SCIENTIFIC AMERICAN

(Condensed from Issues of March, 1894)

ALUMINUM — "The development of the electrolytic processes for making aluminum created a demand for pure alumina. . . . Pure carbon electrodes were necessary, and these were furnished with a fraction of 1 percent of ash. The result was that aluminum was made so that the entire product was over 99 percent pure, which was much better than the regular results obtained by the chemical processes."

ELECTRIFICATION — "Work has been begun on the Baltimore and Washington Electric Railway. The electric line will be only 32 miles long, while the Baltimore and Ohio's steam road is 40 and that of the Pennsylvania 42 miles in length between the two cities."

CONDUCTIVITY — "At ordinary temperatures copper is six times better a conductor of electricity than iron, but the conductivity of each is increased by cold. Copper is ten times better as a conductor of electricity at —100 degrees than it is at the freezing point of water, and the conductivity of iron increases at a still greater rate until iron becomes as good as copper.

ENERGY — "Prof. Langley demonstrates that if a body of coal sufficiently large to last the United States a thousand years should be set on fire, the heat given forth from it would not equal that which the sun gives out in the thousandth part of a second."

HAITI — "Mining interests have hitherto been wholly neglected in Haiti, and her resources in this respect are kept in the background and seldom referred to. Nevertheless, it is well established that gold, platinum, silver, copper, iron, tin, manganese, antimony, sulphur, rock salt, bitumen, etc., exist."

VEGETABLE SILK — "Kapok may be employed in lieu of cotton for preparing a detonating powder by treating it with nitric acid. This nitrated kapok, mixed with pyroligneous ether, and with protochloride of iron having an organic base, yields a reduced fiber, which, differently colored, furnishes a solution of vegetable silk which solidifies in water and may be spun and afterward mixed with animal silk."

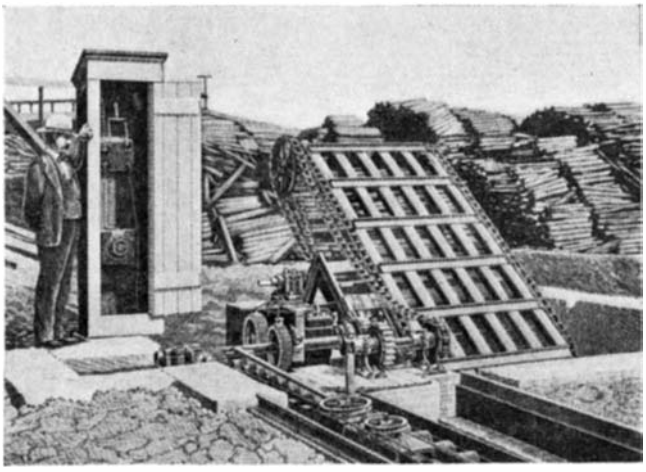
FURNACE LINING — "Magnesia is claimed to be capable of standing far higher temperatures than other kinds of brick, the principal difficulty in using it being the excessive shrinkage to which it is liable when heated. . . . M. Lencauchez claims to have overcome these difficulties, and has exhibited a number of perfectly solid bricks of magnesia, which were as dense as granite, and had been thoroughly shrunk."

CONSERVATION — "Inventive genius has done much for the human race. It has taught mankind to utilize most of the products of nature. Hereafter it must lead to the conservation of natural resources and to the hoarding of natural capabilities. . . . Within a few generations such economies will not be expedients; they will be necessities."

TUBE SERVICE — "A pneumatic tube service between the offices of the various newspapers and news associations of Chicago has just been put in operation. . . . About one minute is required for a carrier to traverse the longest line."

ELECTRICAL DIFFICULTIES — "The want of suitable refractory material for the incandescent lamp filament, the high capitalization required for electric generating plants, the poor economy of the steam engine as a prime motor for driving dynamos, are samples of the difficulties which the electric engineer has to contend with. It is to be hoped that the inventor will dispose of enough of them to make electricity take the place it is fairly entitled to."

POWER LOADING — "At the works of the Illinois Steel Company, at Joliet, Ill., electrically transmitted power is now used in many operations with great economy and convenience. Our illustration represents an electrical apparatus



employed to load steel billets on flat cars. . . . The billets to be shipped are delivered to a long line of rollers, partly shown at the left in the illustration, and are thus carried along until they strike a deflecting plate by which they are conveyed to an endless moving apron, set at an incline, as prominently shown in the picture. This apron first elevates and then drops the billets on the car to be loaded, which is on a depressed railroad track on the farther side. This loading machine is driven by a twenty-five horse power 500 volt motor, the controlling switch and rheostat being conveniently placed in a small switch house."

HORSEPOWER — "It has been estimated that 25,000 horses are employed in the London carrying trade, that their value is a million and a quarter, and that the cost is for food alone £800,000 a year."

ALMOST GONE — "The elevated railroads of New York City carried 221,000,000 passengers during 1893. . . . The number of passenger coaches employed in the service is 1,116, and 75 new ones were added during the last four months."

STEEL SHIP — "At the yard of Arthur Sewell & Co., Bath, Maine, the first steel sailing ship built in America was launched on Feb. 17, 1894. . . . The vessel is rigged as a four-masted ship, being square rigged on three masts, the lower masts and top masts all being in one length."

PLASTIC FLOW — "In the view and understanding of the tendency to molecular flow in all structural material toward a weaker form or condition, especially in tensional members, it is a most important consideration that the factor of safety should be largely increased in every structure in which life and property may be jeopardized, whether it be a machine, a boiler, a vehicle, a building, or a bridge. Absolute safety should be the prime axiom of construction. . . . The measure of the force necessary for the flow of solids varies greatly in different materials, due to varying molecular adhesion. The hardest materials known are no doubt subject to molecular change of form under pressure, but as we can only use the hardest and most resisting material for producing pressure, there is an apparent limit at which we can prove the flow of solids."

AUTOMOBILES — "While waiting until electricity shall have put in its last word concerning the propulsion of vehicles, a warm contest is continuing between steam and petroleum carriages, without counting those actuated by a compressed air motor and that are coming in their turn to take part in this pacific tournament."

THERE ARE STILL

UNDISCOVERED CONTINENTS

COLUMBUS had a definite goal—a westbound sea route to Asia. But what he found was a new continent—a new source of Nature's wealth.

Modern research also has its goals: it, too, is discovering new resources. Starting from the knowns of science, it charts its voyages into the unknown. Behind each voyage is a theory that there is a passageway.

But research doesn't hold stubbornly to its theories. If it finds islands instead of a continent, it accepts them, for it expects the unexpected. It studies their relation to the known lands of science. And on the basis of its increased knowledge, it makes revised plans for progress. In science there is always a continent ahead.

Just what research will disclose can never be forecast. But history has proved that from research flow discoveries of value to mankind. From Bell Telephone Laboratories there has poured a full stream of improvements in the telephone art.

Bell Telephone Laboratories has kept America leading the world in telephony. And its researches have contributed importantly to other arts of communication—to the phonograph and sound-motion pictures, to radio broadcasting and television.

Today, as ever since Pearl Harbor, its efforts in research and design are devoted to the war needs of the nation.

When peace comes, its organized teams of research scientists and engineers will continue to explore and invent and perfect for the improvement of telephony.

BELL TELEPHONE SYSTEM

"Quotes . . ."

"WHEN VICTORY comes, the measure of America's greatness and worthiness will be her ability to turn the war production machinery which has been designed primarily for destruction, into effective peaceful purposes." *Arthur W. Herrington, Board Chairman, Marmon-Herrington Company, Inc.*

" " "

"FREQUENTLY THE lack of a single ingredient of technical information in a plant has resulted in a lost contract, and one of the basic difficulties of small manufacturers has been a lack of adequate research facilities to meet present-day production problems." Brigadier General Robert W. Johnson, Chairman, Smaller War Plants Corporation.

" " "

"GREATER STABILITY in production will pay high dividends in the form of lower unit costs, lower taxes, and lower relief costs, as well as less social and political unrest and better industrial relations within the plant." *Eric A. Johnston, President, Chamber of Commerce of the United States.*

" " "

"IF INGENUITY is the ability to solve problems, this implies the ability to do creative, original work. Unfortunately, the successful completion of an engineering curriculum does not necessarily imply a high degree of ingenuity. If educational institutions have any value in the development of ingenuity, they must stimulate rather than kill intellectual curiosity." Henry T. Heald, President of the Illinois Institute of Technology.

" " "

"WHEN THE HISTORY of this war is written, tribute must be paid to American teachers who, grasping the vital importance of aviation in our national defense, converted classrooms into veritable airports, shops into model aircraft assembly plants, and laboratories into preflight training centers." *Advisory Board, Air-Age Education Research.*

" " "

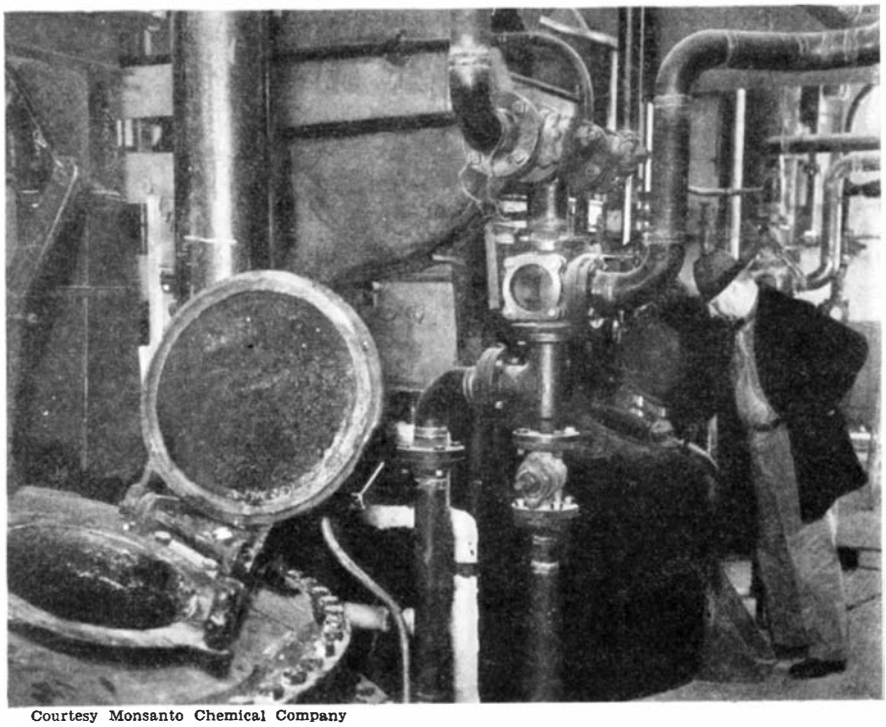
"IF FARMERS would only consider farm woodlands and farm forests as cropland, and carefully cut selected trees every year—the ones that are ripe for harvest—they would be surprised by the amount of their returns and they would certainly aid the war effort." H. H. Bennett, Chief of the Soil Conservation Service.

" " "

"RECONSTRUCTION AFTER this war means the rebuilding and restoration over vast areas of the world of all the facilities and essentials of modern civilization, laid waste by the flames of an incendiary war, the most destructive in human history." *Eugene P. Thomas, Chairman, National Foreign Trade Council.*

CHEMISTRY IN INDUSTRY

Conducted by D. H. KILLEFFER



Courtesy Monsanto Chemical Company

Reaction kettles in which synthetic resins are produced

Plastics Tomorrow

Will Plastics Become the Miracle Workers Predicted by Some Enthusiasts? Practical Experience, Gained by the Industry, Shows What They Can and Cannot be Expected to Do. Plastic Ships, Automobiles, Houses? Economic Limitations Give the Answer

PLASTICS are prominent in plans for the post-war world. They should be. Nothing else equals the versatility of these synthetic products of chemistry's pots and kettles, and nothing else possesses such promise for rebuilding our war-torn industrial economy. Yet plastics are less novel and strange than one might be led to believe by enthusiasts who have only lately discovered their amazing variety and usefulness. Actually, an important body of experience in the fabrication and application of plastics has been accumulating over several decades, and this is now being put to widening use with an effect almost of the miraculous. Insoluble problems of production in other materials seem to vanish when plastics enter the plant. That heightens the miracle. Serious suggestions are being advanced that even our houses, our automobiles, our ships, may soon be drawn cheap, complete, and finished from the wonderful grab bag of plastics.

Now, one would be rash indeed in this swiftly moving age to risk stating that anything is impossible, particularly in plastics. But enthusiasts often mislead themselves. That is what seems probable in this instance. Many essential limitations of the plastic art, well known to experts, are being overlooked. Even when these limitations are considered, however, the future of plastics is still immensely attractive. Just now, plastics achieve special prominence by taking the places of scarce and restricted materials that have gone to war. Tomorrow, their value and versatility will secure for them important places of their own in our industrial world.

Just to be sure of what we are talking about, it would be well here to define plastics. Actually the term includes all materials capable of being molded by pressure. In the currently accepted sense of the term, however, glass, ceramics, metals, and a number of natural gums and resins are ruled out and the field of plastics embraces primarily the synthetic resins, and compositions made from them, which are capable of being formed by heat and pressure. To these must be added a number of semi-synthetic products, particularly those derived from cellulose by chemical treatment (cellulose nitrate, acetate, butyrate, and its ethers, particularly methyl and ethyl cellulose), and moldable products made from the lignin of wood.

The plastic as molded commonly consists of a mixture of a synthetic resin with a filler of fibrous material added to give the desired characteristics to the final product. For example, a mixture of phenol and formaldehyde may be carried partly through the chemical reaction converting it to resin and then mixed with wood flour or glass or asbestos fibers to form the plastic mass to be shaped in a hot mold under pressure into a distributor cap for an automobile engine. Or a similar, partly formed resin may be spread upon layers of paper, canvas, or wood veneer and the whole pressed hot into slabs or sheets.

The function of the filler in a plastic usually is to offset some shortcoming of the resin alone (brittleness, for ex-

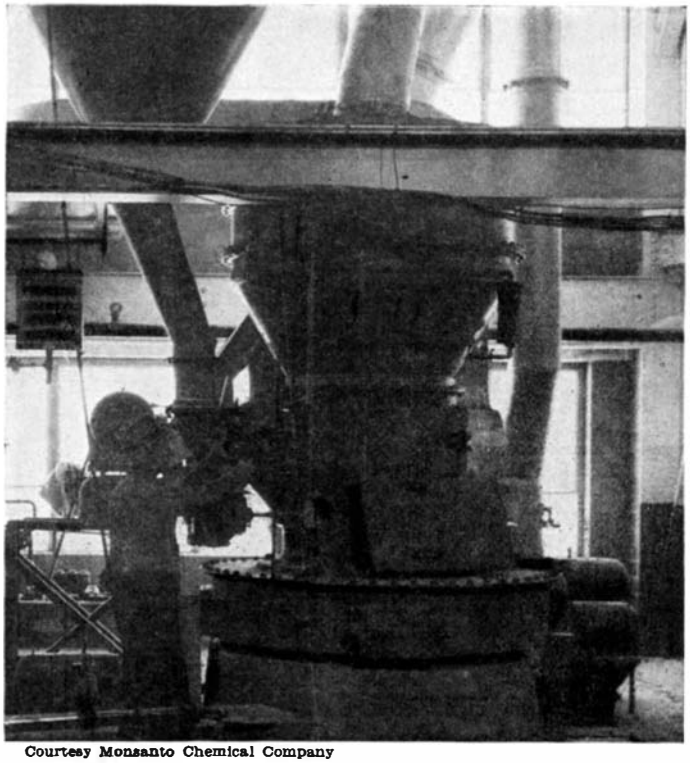
ample) and to impart some particular property to the finished article. Other articles—pipe bits, beads, and the like—may consist of practically pure synthetic resin with only coloring added.

Even when so defined and limited, the term plastics covers a vast number of different materials having properties of the utmost diversity.* Some resins are as tough and elastic as rubber; others are as soft as chewing gum; still others are semi-liquid, resembling thickened fatty oils; and some are hard, brittle, and almost glassy. Indeed, the hundreds of different industrial plastic materials suggest that the principal similarity between them lies in their common synthetic origin. Upon that great diversity of properties depends the extraordinary breadth of usefulness of these synthetics. It also prevents generalizing about them, since a statement true of one is quite sure to be entirely false if applied to some other. On the one hand certain phenol aldehyde resins possess extreme resistance to solvents of all kinds; but others of even the same family are useful because they can be dissolved with relative ease in linseed or tung oil. Certain transparent resins permit the free passage of ultraviolet light, a valuable property in some applications; but this property must be nullified if these plastics are to be used in the windows of high-flying airplanes where ultraviolet can quickly cause serious sunburn.

COMPETITION OF MATERIALS—To class such a variety of materials together is quite impossible from the layman's point of view. Indeed, they possess little beyond their origin in the pots and kettles of the chemical industry to fit them into a single class. Their competition with other products comes from every direction; metals on the one side and wood and drying oils on the other serve some of the same purposes as are served by synthetic resins and their plastics. It has even been seriously suggested that houses of wood and stone will give way to plastic residences; that steel and the light metals, aluminum and magnesium, will feel sharp competition from plastics; that vegetable oils now long used in paints and varnishes will give way before synthetic resins.

The great value and diversity of these synthetics recently led Robert J. Moore to suggest a fourth kingdom, the synthetic, be added to the traditional three—animal, vegetable, and mineral—kingdoms of our childhoods. While the intention was to include in this new realm all the vast range of products of chemical synthesis, Dr. Moore's suggestion applies with special force and aptness to plastics. To proclaim that plastics provide the key to post-war prosperity is almost in the same vein as would be crediting that significant role to the animal kingdom. The important difference lies in the fact that plastics must be manufactured and thus will provide opportunities for the exercise of ingenuity, jobs for many people, and useful employment of capital.

In the swift recent rise of the plastics industry to outstanding prominence, the actual volume of its output has been overlooked. That is not strange since the figure increased by more than 50 percent in the two years between 1940 and 1942 (the latest year for which reliable statistics are available). The United States Tariff Commission notes that production of synthetic resins in 1942 reached a total of nearly 427 million pounds, including all types whether used for plastic molding or not, but without the large and important class of plastic cellulose derivatives. Furthermore, their average value was nearly 40 cents a pound. It is, of course, true that plastics are generally somewhat cheaper than the pure resins from which they are made, but even at that they are obviously not cheap enough to compete successfully with many natural substances—wood, for example—except where some special advantage is gained through the special properties of the plastic.



Courtesy Monsanto Chemical Company

Before synthetic resins are combined with fillers, they must be powdered in a roller mill such as the one shown

Because plastics are readily and cheaply molded into intricate shapes, their field of usefulness is immense, but not limitless in a practical sense. The fact of molding itself immediately establishes certain economic limits. It naturally presupposes a mold and that entails a serious problem of constructing one to serve. Obviously the construction of a mold large enough to mold a ship or a house would present engineering difficulties of the first magnitude. To justify the labor and expense involved in such an undertaking, many thousand identical units would have to be produced from each mold, in order that no one of them would be unduly burdened with the immense first cost. The same reasoning holds for the manufacture of even small items. Buttons, for example, can readily be molded of plastics of several kinds, but the operation requires the construction of a hardened steel mold for each type and size of button to be produced. If millions of buttons are needed, then the cost of the labor involved in cutting the initial mold can be readily absorbed, but the production of a few dozens or even hundreds of identical buttons would be prohibitively expensive.

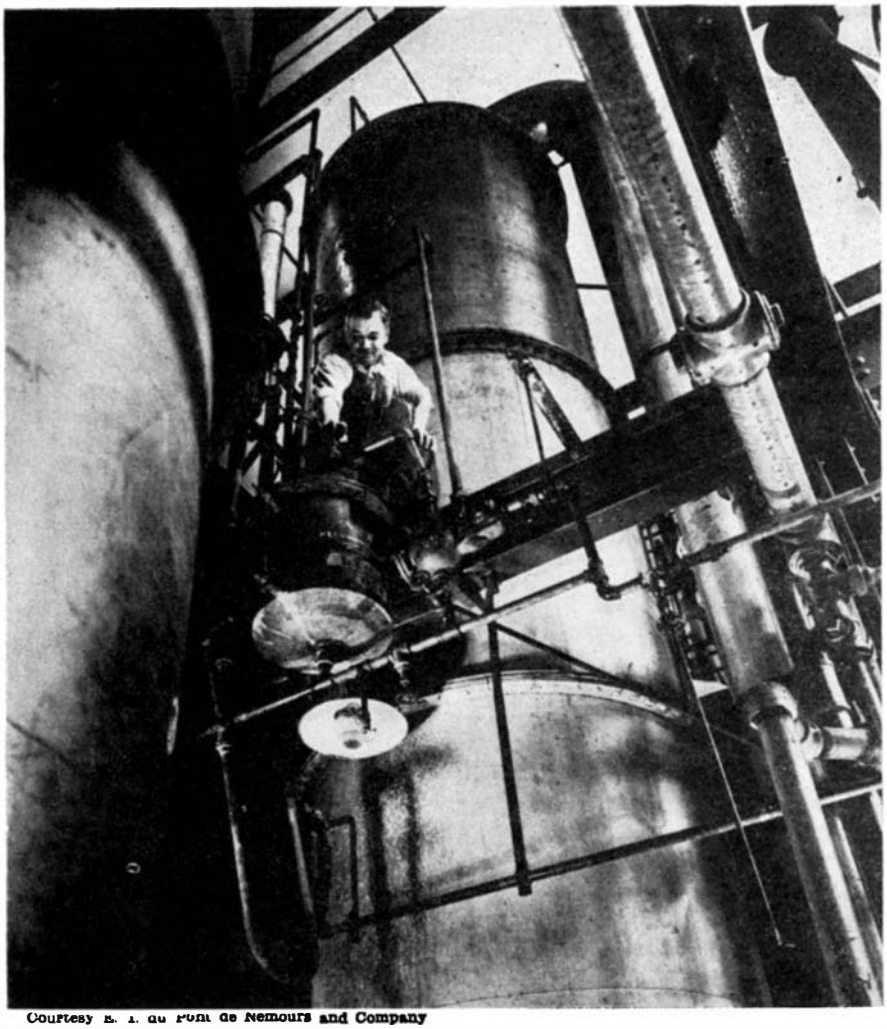
Obviously, then, the plastics industry must depend for success upon quantity production of vast numbers of identical items. There are exceptions to this as to all rules, but, generally, competition with other methods of attaining a like result definitely limits plastic technique to the production of vast numbers of exact duplicates of the original.

For the benefit of those who see in plastics a threat to other industries, it will be well to compare current output of synthetic resins (decidedly the highest yet recorded in the industry's history and still growing) with that of other materials. The present threat to wood and steel is insignificant since the ratio of outputs is of the order of 500 to 1. Set alongside aluminum and magnesium, plastics show up better, with ratios of production 7.5 and 1.5 pounds of the metals respectively to one of plastics.

NOT REPLACEMENTS—Clearly, the future of plastics does not depend on their ability to replace completely any of these important major materials. Rather, they will find useful niches for themselves where their peculiar values will supplement those of the commoner materials. It is foolish to imagine entire houses molded from plastic. As has been noted, the extraordinary engineering problems of constructing a mold large enough to form even a single room quickly throw out such ideas even if the cost of material required were not too high to think about. On the other hand, the valuable properties imparted to wood veneers by modern techniques of laminating several layers with weatherproof synthetic resins as binders have given the architect and builder the equivalent of a new material of construction.

Instead of confining their plans to wood planks of the sizes ordinarily

*For a comprehensive survey of specific plastics types and applications, see page 163, October 1943 issue of Scientific American.—*The Editor.*



Courtesy E. I. du Pont de Nemours and Company

Formaldehyde, made here, is essential in two important families of plastics

available, architects can now utilize a few relatively thin sheets of plywood of large area to form either exterior or interior walls. Building costs can thus be reduced by replacing man hours of labor needed on the site with machine hours in a plant forming the units of the building. Advantage can be taken in this way of the cheapness of wood as the base material, with synthetic resins employed to overcome its deficiencies.

A similar technique has been outstandingly successful in the construction of swift PT boats and Mosquito bombers. Since these units are decidedly too large to be economically molded as single pieces, they are produced by the assembly of units than can be molded to the best advantage when all factors are considered. These methods have been developed to a point of general practicability in the rush of production for war; plants for applying them are already built and can be converted with little difficulty to peace-time production.

A HUNDREDWEIGHT OF PLASTICS—The construction of automobiles from both light metals and plastics has been seriously proposed. Both will undoubtedly be widely used but neither can be expected to exclude the other; certain parts of the car will of necessity still be made of steel. The quantities of plastics required by the automotive industry even as supplements to other materials becomes staggering. A recent estimate suggests that 100 pounds of plastics might readily be used in each vehicle. Even that amount would consume the entire present-day production of the plastics industry if the output of cars should even approach present estimates.

Obviously, then, the plastics industry must grow tremendously if it is to fulfill its post-war promise. This fulfillment need not involve any techniques not already reasonably well tried and immediately available for use. The industry is yet small as industries go, but it contains the germs of substantial growth. It will bear close watching, but it is not a miraculous answer to universal needs. The sooner that general thinking is based on this fact, the sooner will the practical possibilities of the future of plastics be realized.

PHOSPHATE FEEDS

Supplied from Rock For Animal Use

ANIMAL diets normally have included relatively large quantities of skim milk, supplying both protein and phosphorus, but the demand for milk to be powdered for overseas shipment to our armies and our allies leaves little over for farm animals. Meat scraps, too, have become scarce in feeds. Protein is readily supplied in the form of various seed meals, particularly soybean meal, but these do not supply the phosphorus also required.

The best source of phosphorus is bone meal; failing that, phosphate rock is being processed to make available the required element. Natural rock phosphate contains fluorine and this must be removed to make it suitable as a feed. Fusion of the rock by heat and conversion to metaphosphate by treatment at high temperature with phosphorus pentoxide are two of the several methods being investigated to produce a feeding grade of phosphate from the rock. The Tennessee Valley Authority is studying the problem and fused phosphate rock is already being supplied to stock raisers by veterinary firms.

ALCOHOL SOLUBLE

Lacquer Component for Many Purposes

A NEW grade of nitrocellulose for use in lacquers and possessing improved solubility in alcohol has recently been developed by the Hercules Powder Company. The usual grades require mixed solvents (alcohol and ether) or esters (butyl acetate, for example) to dissolve them for use in lacquers. The new product dissolves in alcohol containing minimum amounts of other solvents and the solutions can be employed for many special lacquer purposes. The saving of scarce and more expensive solvents is important in the present emergency.

LOW-LOSS INSULATION

Provided by Chemistry for the Electrical Industry

PROBLEMS of insulation for the swiftly expanding range of high frequencies employed in modern electrical applications are being solved by polystyrene plastics of specially high purity, according to John J. Grebe, Director of Physical Research, Dow Chemical Company, in accepting the 1943 Chemical Industry Medal.

An extremely low dielectric constant can be obtained with polystyrene and other hydrocarbon resins by elimination of impurities and of additive agents that might have molecular or atomic resonances at the electrical frequencies encountered, Dr. Grebe explained. In this way, polystyrene, which the speaker called the "pig iron" of the plastics industry, attains properties essential to the insulation of conductors carrying currents of ultra high frequency at minimum power loss.

Recent developments employing ultra high frequencies that will be benefited by low-loss insulation include radio locators vital in the present war and high-frequency heating that may become the cooking method of the future. These are in addition to radio and television applications.

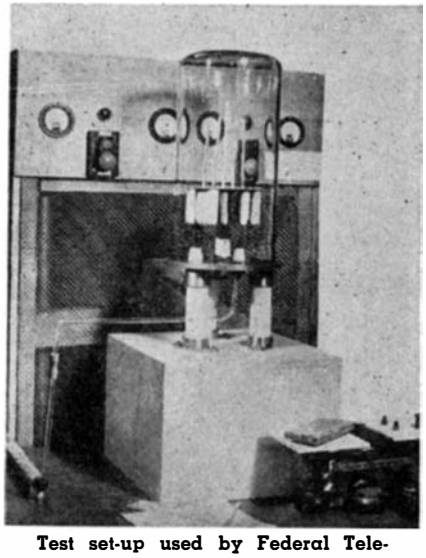
Electronic Processing

Through the Use of Such Electronic Processing Agents as Radio-Wave Components, Supersonic Waves, X-Rays, Ultra-Violet Rays, and Infra-Red Rays, New Methods of Producing Desired Physical and Chemical Changes in Materials Have Been and Are Being Developed by Industry

By JOHN MARKUS
Associate Editor, Electronics

ELECTRONIC control of processes such as baking, drying, hardening, annealing, painting, and gluing has progressed far in recent years, and the first era in the application of electronics to industrial processing of materials is ended. Now we are entering the second era, in which the invisible electronic agents are themselves doing the processing. The accompanying tabulation identifies these electronic particles and rays with a few of the material-changing jobs that they are actually performing today in industry.

The manner in which things entirely invisible can do the work of baking ovens, paint brushes, chemical agents, and nature itself affords a series of stories best told by describing typical industrial applications in each category. With the attention of the entire world devoted to food problems today, the role of electronics in processing food materials logically comes first.



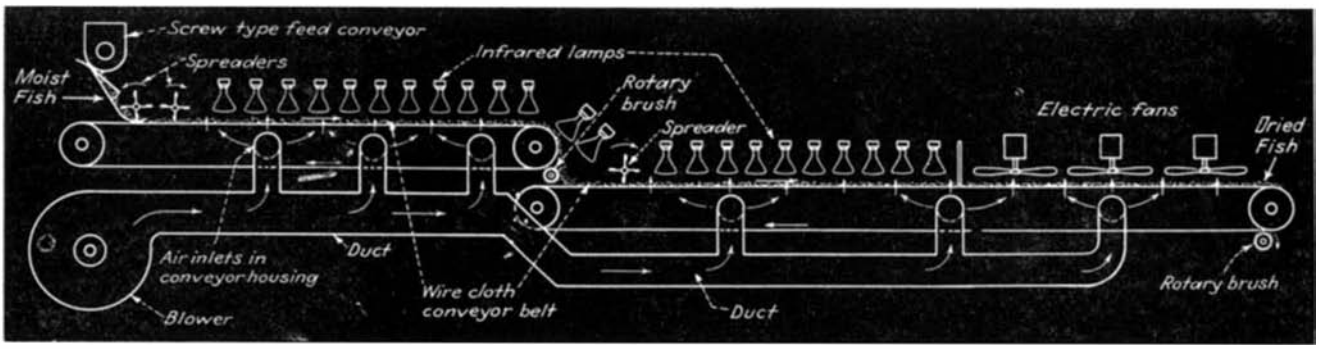
Test set-up used by Federal Telephone and Radio Corporation for dehydrating, by dielectric heating, food samples which have previously been compressed. To expedite removal of water, the space within the inverted bell jar and surrounding the food samples is evacuated

One of the latest developments in electronic processing is the use of radio-frequency energy for dehydration of food. With this process, the removal of 99 percent of the moisture content is achieved without injury to compressed vegetable blocks. Older processes permitted the efficient removal of only about 95 percent of the moisture, leaving enough to permit the formation of mold. Reduction of moisture content below 5 percent by previously used means often produced "case-hardening," a toughening and blackening of the skin of the product. Vegetables that have been dehydrated by the electronic method do not exhibit this deleterious effect and are not expected to deteriorate for a period of one to two years.

COMPRESSED FOOD DRIED—The electronic dehydrating process consists of placing compressed blocks of food between metal plates so that the food becomes the dielectric of a condenser. The metal electrodes are connected to a vacuum-tube generator of high-frequency energy. Losses occur in the dielectric of capacitors and, since the food material is not a good dielectric, considerable heat can be generated in it by the molecular friction caused by the rapidly alternating electric field. Heating of the food takes place from the inside outward to the surface of each block in much the same manner as a diathermy treatment heats the interior of the human body. Food dehydration is thus performed by the same means as is employed for dielectric heating in industry for gluing wood together, heating plastic preforms, and doing a host of other difficult heating jobs.

An electronic heating unit in use in a Fairchild aircraft plant for drying glue between wood strips. Intense high-frequency fields are applied to strip-clamping plates

Dehydration of milk by the conventional processing method removes some 90 percent of the water content and produces a powdered product that has adequate storing qualities in temperate



Simplified diagram of an infra-red unit for drying shredded salt cod in a continuous operation

climates but that does not stand up well in the tropics. Further dehydration of this product by electronic means removes all but 1 percent of the water content and provides a powdered milk that withstands tropical heat and humidity, yet can be readily converted back to a palatable liquid by the addition of water.

Some of the foods that have been successfully dehydrated so far by dielectric heating are shredded carrots, beets, cabbage and onion flakes, and riced potatoes. Roasting of coffee beans and other materials and controlled burning operations may also be accomplished by the vacuum-tube equipment. Results of the electronic processing so far employed indicate that very little, if any, adjustment of the equipment is necessary during processing periods. Operators need no technical knowledge of the electronic apparatus.

Shredded salt cod-fish is another food that is benefiting by electronic heating. About 60 percent of the residual moisture left by the method of natural drying can now be removed. Reduction of the moisture content to 43 percent is necessary for freedom from possible deterioration in warm climates. For this purpose infra-red lamps, which give out radiations whose frequency is between that of radio waves and visible light rays, are being used in one fishery.

LONG WAVELENGTH LIGHT—The flaked salt cod is passed under the infra-red lamps on a wire-cloth belt while air is blown through the flakes to carry away the moisture and cool the fish. This use of long wavelength light has resulted in more speedy drying of the fish flakes, as well as a better product, than when the formerly used cabinet dryer was employed.

Other food products that have been successfully dehydrated by infra-red radiations are sweet potatoes, turnip greens, carrots, and precooked beef and pork. With these and other materials the radiant heating produced by the infra-red method owes its success largely to the high rate of heat transfer that is obtained as compared with conventional hot-air ovens.

Supersonic waves, or sound waves of such high frequency that they are inaudible to most human beings, hold promise of an increased number of applications in the post-war period. These sound waves can be generated by a vacuum-tube oscillator that is connected to a quartz crystal. This crystal then converts the high-frequency electrical alternations into mechanical vibrations and radiates energy in the form of intense inaudible sound waves. The sound waves so produced have been found particularly applicable to the processing of liquid materials in which rapid mixing of small particles, or emulsification, is required.

Other methods of producing these supersonic waves include the use of a metallic magnetic material suspended in the induction field of the coils forming the vacuum-tube circuit, so that the metal is free to vibrate at the induced frequency. Another method utilizes the same principle as that of the dynamic

Electronic Agents and Jobs That They are Doing in Industry

Infra-Red Rays

- Dehydration of beef, pork, and other meats
- Dehydration of sweet potatoes, turnip green, carrots, and other vegetables
- Drying of fish, such as salted cod
- Drying of precooked pork and beans
- Fast baking of paint on automobiles, tanks, lacquered bombs, and other painted objects moving on conveyor lines

Ultra-Violet Rays

- Sterilization of drinking water
- Tenderizing of meats
- Killing bacteria and germs in air and in materials, such as for prevention of contamination in handling blood plasma, pharmaceuticals, and foods
- Action on light-sensitive films and papers, as in photostat machines and in printing of movie film

X-Rays

- Activation of molecules of water and other solutions, making them unstable and highly chemically reactive
- Decomposition of dilute solutions of organic compounds, with liberation of carbon dioxide, hydrogen, and oxygen
- Oxidation of ferrous sulfate
- Activation of catalysts in presence of moisture
- Reduction of potassium nitrate
- Denaturing and flocculating of cell proteins
- Changing composition of genes and establishing mutations

Supersonic Waves

- Stimulation or destruction of bacteria in food products
- Production of smoother milk, ice cream, mayonaise, and other food products by emulsification, as in homogenization of milk
- Acceleration of the aging of wines and spirits
- Acceleration of chemical reactions
- Transformation of crystal structures
- Precipitation of smoke
- Transformation of chemical compounds
- Flocculation (movement into large aggregates) of suspended particles or gas bubbles in liquids
- Treating seeds to stimulate plant growth

Electric Fields—Charging Particles

- Charging abrasive particles with high voltages produced by kenotron tubes, so points stand upright when abrasive falls on the adhesive paper
- Charging particles of paint so they will distribute themselves uniformly when sprayed onto irregular-shaped charged objects
- Removing foreign particles, such as dust, smoke, or pollen, from air by charging the particles just before they pass through oppositely charged metal attracting plates
- Suppression of smoke in ships, industrial plants, or large buildings by charging smoke particles and attracting them to charged collecting plates
- High-voltage sputtering of thin metallic films on surfaces

Electric Fields—Dielectric Heating

- Killing insects or larvae in grain, cereals, on plants, and so on
- Roasting peanuts
- Popping corn
- Cooking steaks, hot dogs, and other meats uniformly throughout
- Toasting bread or buns
- Baking bread and other bakery products
- Baking ceramic products
- Heating rubber during processing
- Preheating pellets or blocks of thermosetting plastic material prior to molding
- Drying lumber, textiles, paper, and other materials under controllable conditions
- Drying glue in laminated wood products such as aircraft propellers and structural plywood parts of airplanes
- Providing uniform heat during certain processes of converting chemicals into cloth
- Curing plastic objects after molding

Magnetic Fields—Induction Heating

- Hardening surfaces of crankshafts, gears, and other steel objects
- Flowing a 30-millionth inch thick layer of tin uniformly on steel strip to give a smooth surface without pinholes
- Annealing local portions or all parts of steel objects
- Driving out gasses from metals, as in degassification of vacuum-tube electrodes during evacuation

speaker contained in radio receivers, but employs a metal bar as the vibrating member in place of the parchment cone. This latter device is also proving quite successful in the flocculation and removal of suspended particles in smoke and fumes for the United States Bureau of Mines

The electrostatic charges that make people jump when they touch a metal doorknob after walking across a rug on a dry, cold day are being put to use in two radically different ways, both of which improve the quality of their respective products. In the manufacture of sandpaper, the abrasive particles are first intentionally charged to a high voltage, so that all have the same kind of charge (either negative or positive). The adhesive paper is pulled over a metal table that is charged continuously at this same high voltage and of the same polarity. Since like charges repel, and since the charges on the abrasive particles are strongest at the sharpest points, the particles all aline themselves with their sharpest points upward as the abrasive material is sprinkled on the moving paper. The result is a much sharper, faster-cutting sandpaper. The voltages for both charging jobs are produced by rectifying tubes known as kenotrons, which change alternating current to direct current.

ELECTRONIC PAINTING—Another application of electrostatic charges is in spray painting of irregular objects. The object and the particles of paint are charged in such a way that the paint is deposited uniformly on all surfaces, no matter how deep the irregularities in the shape of the object. A better job, in less time, with less paint, not only improves the quality of the processing operation but also reduces its cost.

Still other applications of electrostatic fields include smoke precipitators for chimneys and air cleaners for locations where dust, pollen, or other foreign particles in the air are undersirable.

In laboratories throughout the world, other electronic agents have also shown definite adaptability in producing physical or chemical changes in materials. Thus, with the high-speed neutrons of atom-smashing cyclotrons, any of the 92 known chemical elements can be changed into at least one other element by bombardment of atoms, and radioactive forms of every element can be produced. These radioactive materials can be used in place of radium, with greater safety, greater ease of control, and lower cost. Already, artificially radioactive phosphorus has been administered internally to patients in the treatment of leukemia, and radioactive iodine has been used to carry radiations to the thyroid gland.

In these and a host of other processing applications, then, electronics now offers definite improvements to speed and improve the final production of needed materials. Many other applications are undoubtedly also in actual use but under restrictions of military secrecy so that they will not become generally known until after the war. And for the future, electronic processing promises entirely new materials, improvements of existing materials, and speeding up of present processing methods with resulting lower prices.

HAND-GRENADE FUSES

Checked for Correct Powder Content

THE ELECTRON-TUBE family tree is a large one. Each of the many kinds of tubes is able to operate successfully on its own, or, when desired, it can be used in co-operation with other members of the family. Amplifiers, rectifiers, photo-tubes, X-ray tubes, thyratrons, and any of the other kinds of tubes will form effective co-operating agents when industry so desires.

Bomb fuses, placed in cylinders on a belt, are carried through the X-ray machine where charge is checked

A dab of red paint shows on the improperly charged fuse, which was also detected on the meter graph

An excellent example is the joining of hands by photo-tubes and X-ray tubes in an automatic arrangement for checking to see that hand-grenade fuses have the correct amount of powder in them. In this equipment, developed by General Electric engineers, the fuse assembly, consisting of a metal tube containing two powder charges and a slow-burning fuse, is placed in a cylinder on a moving belt. The belt carries each fuse past an X-ray machine which looks into the situation to see how much powder is inside the assembly. A glow appears upon a fluoroscopic screen and a photo-tube measures the amount of light. If the powder charge is correct, nothing happens.

But if the powder is too scanty to do a good job, lots happens: A bell rings to summon an attendant; a red light flashes; a daub of red paint is smeared on top of the defective fuse and the reject is recorded on a meter chart.

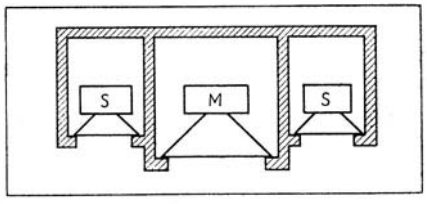
This combination of two electron tubes will test 4000 fuses an hour.

LOUDSPEAKING TELEPHONE

Eliminates Use of "Talk-Listen" Switch

TWO-WAY loudspeaker telephone service between two or more locations, so that persons conversing may speak and listen at a distance from the apparatus without operating the usual "talk-listen" switch found on other intercommunicators, is obtained by using an acoustically balanced combination of speakers at each station to overcome acoustic feedback and resultant howling.

Each station in the system is arranged with three loudspeakers. One of these is employed as a microphone, and is placed midway between the other two which have their voice coils connected in parallel and out of phase with each other. When one speaker impresses a portion of a sound wave of increased air pressure on the microphone there will be an equal and opposite pressure, or decrease in a sound wave, on the other speaker. This results in cancellation of the two waves and therefore no net movement of the diaphragm of the microphone. A perfect balance cannot be obtained in practice but a considerable degree of cancellation of the sounds issuing from the two speakers is thus effected and howling due to feedback through the system is virtually eliminated.



Mounting the loudspeakers (S) and microphone (M) of the new intercommunicating telephone in separate padded compartments prevents practically all backside radiation effect

The speakers and microphone are mounted in a cabinet, each unit separated from the others by a partition. The remaining space in each enclosure is partly filled with sound-absorbent material so that the backside radiation of sound from the speakers is largely absorbed.

Engines of The Air

Highly Reliable Power-Plants have been Developed for Military Aircraft. These Will Have Direct Influence on Not Only the Future of Private and Commercial Flying, but on Engines for Automobiles. The Helicopter Poses Power-Plant Problems of its Own

EVEN THOUGH many war-time developments are still shrouded in mystery, the present status and future possibilities of the aircraft engine are becoming a little clearer. Outstanding engines, the war-time culmination of many years of development work, have done much to secure supremacy in the air for the United Nations. They will assure commercial and private flying of the post-war period of one essential—a highly reliable power-plant. Methods employed in their manufacture have led to advances in processing, materials, and tolerances which have aided and will continue to aid many other branches of American industry. And the efficiency, lightness, and power possibilities of aviation engines will undoubtedly have their influence on the post-war automobile.

The United States has led the way for many years and is still leading in the design of radial air-cooled engines. Now Wright Aeronautical has brought out the Cyclone "18" with the highest horsepower figure (2200) which the War Department has ever permitted to be published. The "18" is more powerful than the Cyclones which power the Flying Fortresses and is now in quantity production for heavy bombers, fighters, and transports.

The steady and rapid increase of the power output of aviation engines has not been due to the introduction of striking novelties, but rather to engineering development and refinement, made possible by clever technical brains, a world of experience, and unlimited funds and equipment at the disposal of manufacturers.

Lt. Col. Carl R. Borkland, A.A.F., and Myron B. Gordon, vice-president of Wright Aeronautical, inspecting the powerful, complex Cyclone "18"

The Cyclone "18" is not very different in appearance from previous models. But despite its tremendous power the engine has a diameter of only 55 inches—the same diameter as that of the original nine-cylinder Cyclone which was introduced in 1927 with a rating of only 525 horsepower. The engine has passed a special 150-hour run and extensive flight tests. Its 18 cylinders are built in two banks of nine cylinders each with a total displacement of only 3350 cubic inches. Information in specific military installations is still restricted, but it is known that the Cyclone "18" has made its first transport appearance in the Lockheed Constellation, a 60-passenger high-speed transport.

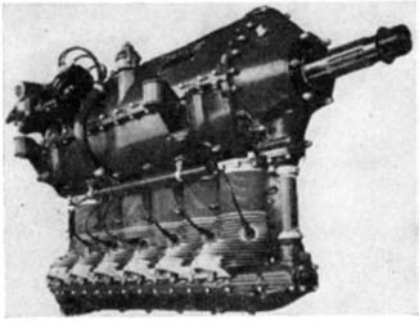
DESIGN FEATURES—Despite the lack of revolutionary principles in the new engine, there are still some splendid features in the design. Thus the nose section is so designed as to permit a close-fitting cowl and to reduce head resistance. A steel crankcase permits more power to be derived from the engine than does an aluminum crankcase. Magnesium is used liberally to keep the engine light, and the specific weight is just a fraction over one pound per horsepower—an extraordinary figure when it is remembered that a good truck engine weighs at least 11 pounds per horsepower.

Since the Cyclone "18" will power high-altitude military aircraft, it is equipped with a two-speed, gear-driven supercharger. To absorb the vast power of the engine the big propeller is provided with very broad blades, and to keep the blade-tip speed well below that of sound, the propeller is geared down to less than half crankshaft speed.

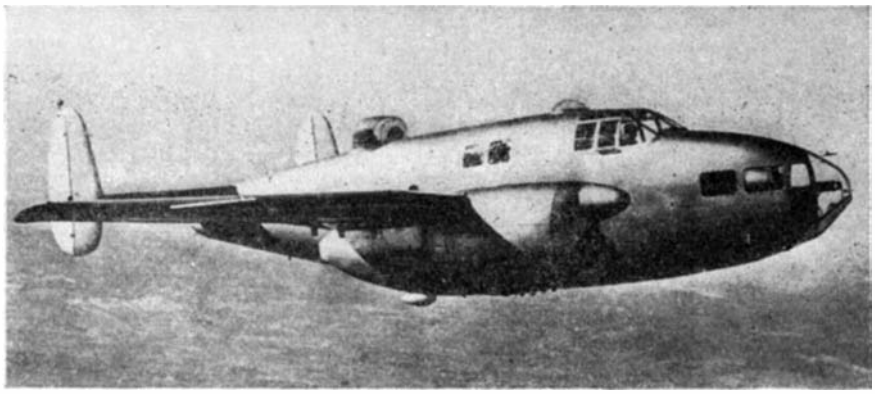
The development of such powerful engines will help commercial aviation greatly in the post-war period and these air-cooled engines already have helped to produce the fastest and most maneuverable tanks in the world.

Not only are engines of immense power being built; engineers are also finding various means of supplementing their power in emergencies. The Germans are said to employ special "dopes," fuels which, injected into the engine, increase its power for a brief emergency, though the engine is thereby completely ruined. Experiments are also being made with rockets or jet-propulsion engines which will give additional thrust for, say, half a minute and help to get an overloaded plane into the air. Auxiliary rockets or jet-propulsion means could also be conceivably used in flight when evading an enemy.

There is still another method of securing this momentary increase in power—a method developed by Pratt and Whitney Aircraft—which consists of injecting water into the cylinders of the 2000-horsepower "Double Wasp." The application of water-injection in aviation was first studied by Pratt and Whitney engineers only about a year ago, and proved so successful that thousands of conversions are now being made and installations are being undertaken on the Republic P-47 Thunderbolts. The water injection device has three advantages. First, the cooling effect of vaporization in the cylinder is greater when water is added than with fuel alone. Second, the susceptibility to detonation which limits the power that can be taken from the cylinder is lessened by the presence of water in the cylinder. Third, it is said that more power is produced because the device permits the use of a leaner mixture from the carburetor. This is but one of many devices and improvements which the war has brought into being in



The six-cylinder in-line Ranger air-cooled engine: Neat and reliable



The Fairchild "Gunner", powered by two Ranger 12-cylinder inverted engines

the airplane engine; a number of them will be helpful in the post-war period.

Because the radial engines have been so successful and have powered such famous aircraft, it is likely to be imagined that they are the only type of air-cooled engines to be reckoned with. Nothing could be farther from the truth. The six-cylinder in-line Rangers, manufactured by Fairchild Engine and Airplane Corporation, have made a splendid reputation for themselves. These in-line engines offer a smaller nose and perhaps less head resistance than the radials and, at the same time, avoid the plumbing difficulties of the liquid-cooled engine. They have proved highly reliable and efficient and are now being manufactured at a satisfactory rate. The inverted six-cylinder in-line Ranger illustrated is capable of supplying 175 to 200 horsepower and is a neat and reliable product.

LARGE IN-LINE ENGINES—There does not seem to be any reason why the in-line principle cannot be applied to much larger engines, even though the specific weight may be a trifle greater than that of the radial. The V-type 12-cylinder Ranger, developing 500 horsepower, indeed has made an enviable reputation for itself. The neat appearance of the Fairchild "Gunner" is in some respects due to the engine. This speedy mid-wing monoplane carries a power-driven turret, is built of plastic-bonded plywood and is designed as an advanced training ship for our aircraft gunners.

Some remarkable engines are now available for the private plane, ranging from 50 to 200 horsepower, beautifully constructed, reliable, much cheaper than anything we could have expected a few years ago. They are doing fine duty in military and naval training planes and in the Civil Air Patrol; they are ready to equip the thousands of private planes which will be in the skies soon after the war is ended. A fine example of the low-power engine is the Continental A Series type, comprising four air-cooled cylinders, horizontally opposed, ranging from 50 to 80 horsepower, and from 170 pounds to 176 pounds in weight. These engines are particularly interesting in that they are equipped with fuel injection, which makes for better fuel distribution, eliminates carburetor or manifold icing, and reduces fire hazards.

Another fine example of an engine for private fiying is the Kinner Model R-540-3. The Kinner five-cylinder engines range from 100 to 175 horsepower and are used in a variety of Army and Navy trainers, at fields both in the continental United States and abroad.

The point to remember about the light engines is that, while they may be heavier in pounds per horsepower, they are in every way as refined and as reliable as their bigger prototypes. Manufacturers such as Wright Aeronautical and Pratt and Whitney have perhaps led the way but certainly the builders of smaller engines have known how to follow and in a few respects to lead the big two engine companies.

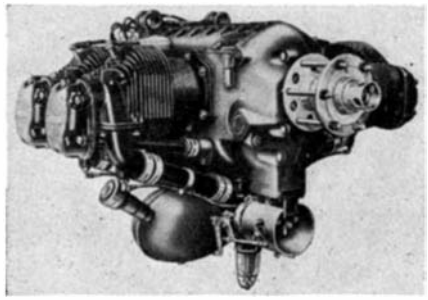
There is one question which a discussion of the modern aviation engine, however brief, should not neglect: What about engines for the helicopter? So far as we know, no special engines for the helicopter have been built as yet, and perhaps no special helicopter engines are needed. But there will most certainly be decided modifications or adaptations of the conventional aviation engines to fit them specifically for helicopter use. Thus, L. A. Majneri, Chief Engineer of Warner Aircraft Corporation, believes that engines for operating helicopters (where the axis of rotation is vertical) should be arranged to have their crankshafts vertical. That would mean that the aircraft radial engine would be disposed in a horizontal position with its driveshaft above and the accessory drives below.

We can perhaps add to Mr. Majneri's views on the adaptations or modifications necessary. It is much more difficult to cool an engine installed in the helicopter, because this type of aircraft may be called upon to hover or to climb vertically, thus receiving practically no cooling air. Therefore, the helicopter engine must be provided with a cooling fan, placed quite close to the cylinders, and, for preference, the fan should be built into the engine itself. Again, the helicopter engine, like the automobile engine, must be provided with a clutch and a free-wheeling or over-running device, because at times the rotor must be free to auto-rotate. When the engine fails suddenly the rotor must be disengaged at once from the engine.

Another requirement is that the engine shall have a high speed of revolution, say 2400 revolutions per minute, while the rotor of the helicopter functions best at a low speed, say 250 revolutions per minute or even less. Hence a powerful gear reduction must be interposed between the two.

A number of writers have raised a plea for integral aircraft power-plants; that is, an aircraft engine which would be self-contained when installed in the airplane. There is still more reason why the power-plant for the helicopter should be an integral one and contain within itself the clutch, gear reduction, cooling fan, and over-running device. A real opportunity presents itself here for the engine builder, particularly for ingenious mechanical designers in general.

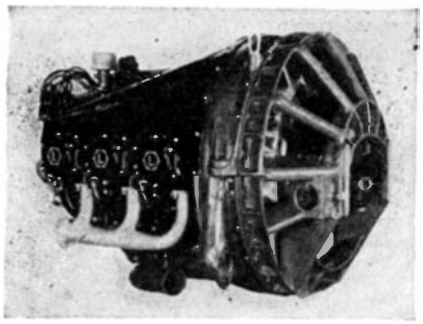
INFLUENCE ON OTHER ENGINES—The air-cooled aviation engine itself will also influence other types of engine construction and, in particular, that of the automobile. We have secured authoritative opinion in this regard. Thus Mr. Majneri, whom we have quoted previously, is quite positive that the air-cooled engine will be re-introduced into the automobile. Re-introduction is the correct word when we remember that for many years the Franklin automobile was equipped with an air-cooled motor and enjoyed much popularity. Of course, it will probably not be the radial air-cooled engine that will be used in the automobile but rather the in-line or opposed-cylinder engines, which obviously lend themselves better to installations in the motor car. The cooling of such engines would be by fan, just as in the helicopter, since the automobile also is at times deprived of a cooling air stream. The specific output of these engines would be in the 50- to 150-horsepower range, the range which will also be the most interesting for the private airplane.



Continental four-cylinder opposed type engine for private planes

We have frequently had occasion to comment on the extreme lightness of the aviation engines. This lightness of the aviation engine will certainly have its repercussion on the automobile engine of the future and will cause aluminum and magnesium to be used more freely than heretofore in the automobile power-plant. But the automobile engine will nevertheless weigh more per horsepower than does the aircraft engine; weight saving is not at such a premium in a surface vehicle.

Continental Motors tells us that one of their light four-cylinder opposed engines of the aviation type will be prominent in a low priced automobile, but they withhold further information. No doubt other companies building light aviation engines today have similar



Derived from aviation practice, this Lycoming "packaged power" unit is designed for surface-vehicle use. The large blower at right provides air for cooling

plans. Lycoming Division of Aviation Corporation is more definite in its information and states that it has developed a self-cooling "packaged power" unit of 162 horsepower, intended for surface vehicles and definitely a derivative of aviation experience. The motor is well worth study. It has a dry weight of 755 pounds and develops 162 net horsepower at 2800 revolutions per minute on 73-octane fuel. It is designed for enclosed or submerged installation. The principal element of the cooling system is a cast aluminum fan or blower mounted integrally with the flywheel and having an outside diameter of 28¼ inches. The 16 blades of the flywheel have an airfoil shape. Half the air cools the engine, half supplies slightly supercharged power to the carburetor.

This "packaged power" unit is a direct relative of the standard Lycoming aircraft engines, with such modifications as battery ignition substituted for the aircraft magneto and the addition of clutch, fan, air baffles, and the like. Reduction in specific weight and immunity to temperature extremes are but two of many advantages which this neo-aircraft engine will bring to the service of surface transportation.

EDITOR'S NOTE: *This is the first of two articles on airplane power plants by Dr. Klemin. The second article will cover other phases of the subject, including high-altitude flying and jet propulsion methods and possibilities.*

TOUGH PLANES

Prove Their Ability to Withstand Abuse

REPORTS appear frequently in the press of Flying Fortresses which limp home with hundreds of bullet holes in wings or fuselage, with engines almost shot away, and the like. Some have asked whether our combat airplanes, bombers, and fighters are really capable of taking such terrific punishment and still bringing their crews back to safety. The answer was well presented recently by Major General Delmar H. Dunton, in an address before the Society of Aeronautical Engineers, who drew on his experience with the Air Service Command to give an authoritative and encouraging picture.

In the General's opinion, the United States is building the finest fighting aircraft in the world, not only for offense but also in their ability to stand up under punishment. We quote his views as regards ability to withstand enemy fire: "Our airplanes have flown home beaten up and smashed to an extent that even the most sanguine of us never dreamed an airplane could be damaged and continue to fly. We have seen in the past few weeks at least two photographs . . . showing two of our battle craft winging their way homeward after having been badly beaten in combat. I happen, personally, to have seen and inspected both of these airplanes. One is the B-17 F which had its tail almost completely severed."

It appears that a ME 109 attacked the Flying Fortress and struck the fuselage at its juncture with the fin, the left wing of the German airplane plowing through fin and fuselage. The impact swung the fighter around so that its propeller chewed completely through the left horizontal stabilizer and elevator of the B-17. The pilot of the Fortress felt the shuddering impact, yet managed to fly his ship back to the edge of the desert. Similar incidents related by the General all give an impression of extreme toughness in American planes.

BIRD-LIKE EYES

Needed by Post-War Civilian Fliers

WITH THOUSANDS of persons planning to buy the promised post-war inexpensive airplanes, a new field of human activity will be opened up that will require more efficient eyes than those which have guided motorists in the past, says M. J. Julian, president of the Better Vision Institute.

"Birds have the sharpest, keenest eyes of all creatures, including man. They need such eyes," says Mr. Julian. "Post-war civilian aviators must strive for bird-like eyes. They will have to train and tune up their sight if they are to avoid the fate of Icarus.

"Civilian fliers will find new conditions of seeing in air motoring. On land it is possible, even with inefficient eyes, to judge distances and speeds by objects along the route of travel, but in the air those guides will be lacking, or are to be seen only remotely in new perspective. A land-lubber taking to the air easily might misjudge the distance, speed, and direction of another plane.

"In operating automobiles, millions of persons have been very neglectful of their eyes. Instead of keeping them tuned up to top efficiency, such persons have depended upon their brakes and the maneuverability of their cars to dodge hazards. But planes have no brakes comparable to the automobile's four-wheel brakes. Also, because of the nature of flying, it will be hard to change in a split second the course of a plane traveling 100 miles an hour.

"In land motoring visual acuity, or sharpness of vision, is the principal concern of traffic officials in respect to eyes of drivers. That also will be important in the air motoring of the future. But other visual factors must receive greater attention," continues Mr. Julian. "Among these are eye coördination, muscle balance, and depth perception. The condition known as aniseikonia, in which the images in the two eyes are of different size, promises to be important. Studies indicate that this defect is not rare. In aniseikonia the eyes find it hard to see on a level line. This condition tends to cause a flier to tilt his plane in cruising and landing. Instead of bending mud-guards, an aniseikonic flier probably would break wings when landing."

SELF-STARTING TIRES

Reduce Rubber Wear When Airplanes Land

WHEN the airplane first strikes the ground, the landing wheels are not in rotation. Therefore, for a few instants, the tires slide along the ground instead of rolling; the resulting landing-impact wear shortens the life of the tires. Impact-wear becomes all the greater when the plane is heavily loaded and lands at a high rate of speed.

It has often been suggested that wheels should be set into rotation before impact, and a variety of complicated devices have been presented to achieve this purpose. Now Henry F. Schippel, of the B. F. Goodrich Company, has invented a pre-rotation method which requires no electric motor and is very simple. All that is required is a series of vanes or fins built into the side-wall of the tire. When the landing gear of the airplane is lowered, the vanes catch the air and set the wheel spinning. Moreover, the

Fins pre-rotate landing wheels

fins, made of rubber and fabric, are so constructed and placed that they fall back into a position flush with the side of the tire on the "upper half" of each rotation of the wheel. Thereby the effectiveness of the device in spinning the wheel is greatly increased, and it is quite possible to have the wheel spinning at the full speed of the airplane itself when it touches the ground.

Besides reducing tire wear, pre-rotation makes the landing smoother.

Chicago's New Subway

Fluorescent Lighting, Piston-Action Ventilation, Reversible Escalators, Automatic Drainage, and Complete Operational Safety are Some of the Outstanding Features of this New Transit System Designed to Relieve Traffic Congestion in the Famous "Loop" Section of the City

PROFITING by the latest advancements made in the safety, comfort, and operational efficiency of underground railway design and construction, the recently completed State Street subway in Chicago is proving its worth as an indispensable transportation unit in that city's vast network of transit lines.

Although conceived originally as an aid to relieving the badly congested traffic conditions in the famous downtown "Loop" section of the elevated rapid-transit lines, this modern transportation facility incorporates many conveniences for its patrons. For example: Escalators furnish effortless access to and from the loading platforms at train level; automatic ventilators provide fresh air and control temperatures within the subway; fluorescent lighting creates a cheerful atmosphere; automatic block signals of latest design insure the safety of train operation.

The State Street subway is a deep-level, twin-tube design, carrying one track in each tube. Construction was started in December, 1938, carried through to completion despite priority restrictions, and the subway placed in operation on October 17, 1943. Costing $34,000,000, this 4.9-mile section is the first of four units to be completed in the city's proposed subway system, which eventually will embrace 55 miles of line at a cost of some $275,000,000. A federal grant of $18,000,000 was secured at the start of construction, the remaining funds being furnished by the City.

Tunneling was employed in much of the subway construction to minimize interference with normal street traffic, although some open cut was made for installing tubes adjacent to the portals. An unsafe, soft soil was encountered in the downtown area, requiring heavy shields and the use of air pressures up to 15 pounds per square inch gage. Tunneling, hand-mining, and multiple bench methods were employed in the outlying areas. Two basic types of tunnels were used; a horse-shoe shaped section for the bench method and a circular section for the shield method. Heavily reinforced concrete walls form the completed tubes.

Where the subway passes beneath the Chicago River, a twin-tube, concrete-lined, prefabricated steel tunnel was sunk in a trench below stream bed to avoid excessive grades in the subway profile. Considerable shoring and underpinning was required for some of the large buildings located adjacent to the subway, while careful excavation and street decking were necessary in the construction of the subway stations.

Stairs lead from sidewalk entrances of the Chicago subway to mezzanine stations; escalators and stairs lead to platforms

Making the connections between the old elevated structure and the ends of the new subway was a complicated procedure, requiring considerable remodeling of existing supporting towers and bracing. The general plan was to build an inclined structure on the ground at each tunnel entrance, carrying a sand-filled roadbed retained by concrete walls. These inclined structures connect to the tunnel portals and slope up to connect with steel inclines at their upper ends. The steel inclines, in turn, connect with the old elevated tracks.

It was desired to maintain the existing three-track and four-track elevated lines running into the downtown loop section from the south and from the north. Consequently, at the junction with the incline connections, the old tracks were spread apart, forming double track run-arounds at one location and one single track and one double track run-around at another. These elevated tracks return to their original locations at points where vertical clearance permits the subway trains to pass beneath them. Since new steel was at a premium, as much of the old steel as possible was remodeled on the site to serve in the steel deck and supporting towers of the inclined structures.

Trains from the elevated tracks are routed either onto the inclines or the run-around tracks by an interlocking system of track switches and crossovers operated by compressed air and controlled from interlocking towers at each end of the subway. Train operations are carefully controlled at all times both in the subway and at the elevated line junctions by the most modern of safety methods known in railway operation. For example, interlocking machines located in towers adjacent to the inclines have a control board on which is mounted a miniature diagram of the interlocking plant's switches, tracks, and signals. Small electric lights behind the diagram indicate a train's exact location at all times as it approaches and moves through the plant. The plant operator sets up the route for each train by manipulating various buttons, thus causing the switches to be automatically positioned and the block signals to be cleared.

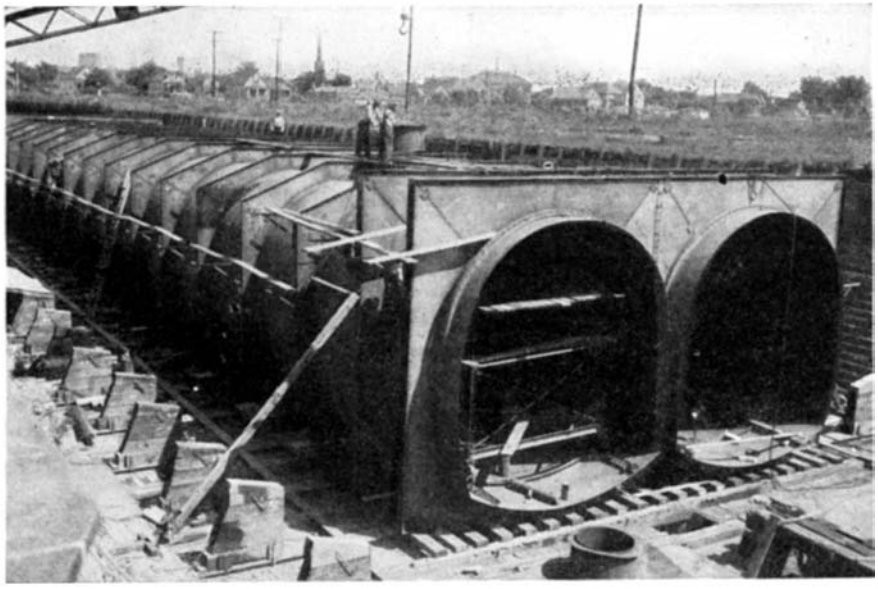
Within the subway tubes, train operations are controlled by a modern block signal system that includes wayside colored lights, approach interlocking signals, and other automatic safety signals found only in the most modern systems.

One of the most important safety devices is the system of electro-pneumatic train-stop mechanisms located at each automatic block, approach, and home signal. Should any train run past a red light at one of these points, this train-stop mechanism engages trip arms on the train, instantly setting its air brakes. The train can not then proceed until its motorman manipulates a stop-release mounted nearby. Automatic train stops and all track switches at interlocking plants are operated by compressed air delivered throughout the subway under a pressure maintained at 65 pounds per square inch.

Safety was paramount also in designing the subway's power system. Motive power is the same as that used for the elevated lines, namely, 600-volt direct current on the contact (third) rails, with parallel feeders and with a return to the substations through running rails. A heavy third rail, weighing 144 pounds per yard, permitted reduction in the amount of copper required in the feeder rails. Contact shoes on the trains are of the suspended over-running type, while the contact rails are supported on porcelain insulators, with expansion joints every 1000 feet.

EMERGENCY PROVISIONS—All contact rails are sectionalized at interlocking plants and at various feeder-point locations. Emergency alarm boxes are spaced 400 feet apart along the subway walls. Switches within these boxes can be thrown, in the event of a train wreck or other emergency, thus de-energizing the contact rail. Another safety feature is a continuous emergency walkway built at car-platform height along the tube walls. Circular stairwells at frequent intervals along the walkways lead to emergency exits at street level. Covers on these exits are equipped with panic-hardware to insure positive operation.

Any water entering the subway through vent shafts, stairwells, portals, or other openings is removed by ten pumping stations. Each installation has a drainage sump below track level and two pumps, one of which serves as a standby for emergencies. Submerged centrifugal pumps are driven through long shafts by a 208-volt, three-phase squirrel-cage splash-proof motor automatically controlled by float switches. Where the subway passes underneath the Chicago River, the motors are located at ground level, operating pumps below by 80-foot shafts. Motors are equipped with line-voltage starters and they range in size from 5 to 50 horsepower.



Sections of prefabricated tunnel that now carries the subway under the Chicago River

Ventilation of the subway is obtained chiefly through the piston-action of moving trains. Chief reason for subway ventilation is to expel the excess heat generated by the electrical operation of trains and other equipment, and not for supplying fresh air within the tubes and stations, as is commonly believed. Taking advantage of air pressure created by moving trains—whose cross-sectional area is about one half that of the tubes—vent shafts were installed from track level to street grade. As trains move through the tubes, they suck in large quantities of air through the vent shafts, at the same time forcing out equal amounts through others. A total of 69 of these vent shafts are installed in the State Street subway.

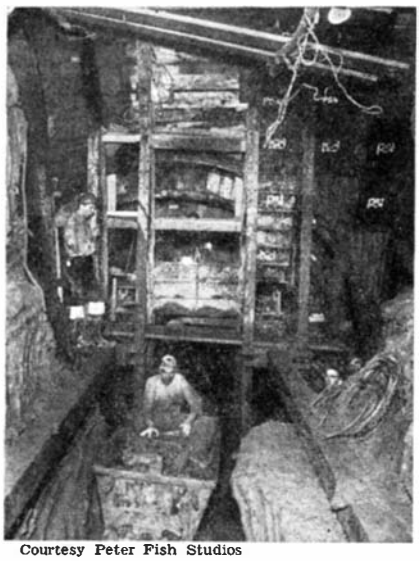
Vent shafts adjacent to subway stations serve the double purpose of providing ventilation and blast relief for loading platforms from the air pressure of onrushing trains. Electrically operated fans provide ventilation during emergencies and for ventilation at the river crossing. In addition, they supplement the piston-action in the downtown stations. There are, in all, 26 of these huge fans capable of furnishing an additional one million cubic feet of air per minute.

LIGHT ASSURED—One of the most striking features of modern subway construction is the fluorescent lighting used throughout the subway stations and loading platforms. The Chicago Subway is a pioneer in this type of subway lighting. An independent incandescent system lights the tubes and provides emergency lighting for the stations. Duplicating alternating-current supplies energize the fluorescent lighting system. In addition, a separate limited system is fed from the 600-volt, D.C. traction power system through a light main extending the entire length of one tube. In the event of a power failure in both the incandescent and fluorescent lighting systems, automatic transfer switches will tap power from the third rail, lighting a small number of lamps, sufficient for emergency operation of the subway.

An atmosphere of comfort, cheerfulness, and efficiency is displayed in the attractively designed subway stations They are of the mezzanine type and are located between the subway roof and street level. Each outlying station has a 500-foot loading platform at train level to accommodate a train of eight 60-foot cars. Some platforms are centered between the tracks while others are loca-

Courtesy Peter Fish Studios

Part of the tunnel excavation was carried out by the circular shield method



Courtesy Peter Fish Studios

Hand mining methods were used in some of the tunnel sections where the nature of the soil permitted

ted on the outer side of each track.

Eight mezzanine stations are located in the downtown section between Congress and Lake Streets, one centrally located in each city block and all connected by a 3430-foot continuous island platform between the two tracks. Short stairway entrances lead from sidewalk level to the mezzanine stations, while reversible escalators and stairs lead on down to the loading platforms 40 feet below street level. Mezzanines are finished in a glazed tile and structural glass, with exposed columns encased with radio-black marble. Cashier-controlled and coin-operated turnstiles, a general facilities room, open phone booths lined with acoustic metal, rest rooms, and a concessions booth complete the mezzanine station facilities.

COLOR-CODED STATIONS — Directional signs, steel columns, and terra-cotta trim for the loading platforms are finished in four basic colors—blue, red, green, and brown—and rotated in the order named to assist the commuter in identifying his destination. Platforms and mezzanine floors are of red concrete to which alundum was added to provide a non-slip surface. Stair treads are fitted with abrasive tile to prevent slipping.

Modern trains could not be secured for subway operation because of priority restrictions. This necessitates the use of existing steel cars of the Chicago Rapid Transit Company until they can be replaced by modern equipment. However, 455 of these units are available; 389 being equipped with two 170 horsepower motors, and 66 being trailers. Each car will seat 52 passengers and has a total capacity of 100.

The State Street subway was designed and built by the City of Chicago's Department of Subways and Superhighways, under the supervision of Philip Harrington, commissioner, with Ralph H. Burke and Charles E. DeLeuw serving as chief engineers. Joseph D'Esposito was project engineer representing the interests of the federal government.

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HIGHWAY CONSTRUCTION

Program for Post-War Is Biggest Ever

A POST-WAR highway program developed by the American Road Builders Association indicates that highway construction after the war will be the largest ever undertaken in this country.

One of the principal recommendations of the report is that a construction program totalling three billion dollars per year be undertaken for a period of five or six years following the war. This is twice the size of the previous record highway construction program which ran close to one billion five hundred million in 1930.

CONCRETE TANKS

Lined for Safe Storage of Gasoline and Oil

MORE than 2000 concrete storage tanks of 25,000- to 2,500,000-gallon capacity are included in the Navy program for storage of gasoline and oil. According to Navy spokesmen, the problem of porosity of the concrete, which permitted seepage of the stored liquid, has been largely overcome.

The Navy, in co-operation with industry, has developed various types of linings for the inside of the tanks, which, in effect, form a big envelope containing the stored fuel and keep it from seeping through the concrete.

For heavy fuel oil it has been found that all that is necessary is to paint the inside of the concrete tank with sodium silicate (water glass), four coats giving a satisfactory cover.

For Diesel oils and gasoline, three different types of lining materials have been developed. One is a vinylite plastic, painted on the interior of the tank. Another is sheet Thiokol, cemented to the interior. The third type consists of Thiokol in latex form in a layer of cotton fabric.

TEST BUILDING

Provides Many "Climates" for Mechanized Equipment

CLIMATIC conditions varying from those in the humid tropics to the freezing Arctic regions may be simulated in a laboratory building recently completed for the testing of Army mechanized equipment, according to *Engineering News-Record.*

The "hot" and "cold" rooms in this building, some of which are large enough to accommodate 60-ton tanks, will permit studies on the effect of extreme weather conditions on both men and machines.

The laboratory is housed in a 54- by 110-foot reinforced concrete frame structure, two stories in height. It is air-conditioned throughout by means of a seven-zone summer and winter system.

The "cold" room, which has a 28-inch-thick floor, 20-inch walls and ceilings, and 12 inches of cork all around, provides temperatures down to 60 degrees below zero, Fahrenheit.

The "hot" room has thinner walls, insulated with mineral wool. Here temperatures up to 150 degrees, Fahrenheit, in combination with humidities as high as 95 percent, can be produced.

PLYWOOD GIRDERS

Offer Advantages for Building Construction

GIRDERS with plywood webs and timber flanges are now being used extensively in the Middle West.

Many advantages are claimed for this new product, which has been used on over 80 projects. Advantages include: (1) fabrication in a shop, which permits rigid control of manufacturing processes and assures maximum strength of members; (2) the girders are rigid, deflection being less than 1/360 of the span at 1200 pounds per square inch extreme fiber stress; (3) lumber demands are low and the material required comes in stock sizes; (4) girders are easy to erect, which permits rapid field construction; and (5) few strategic materials are required.

As shown by the accompanying photograph, the web consists of a single thickness of standard fir plywood with the outside grain vertical or at right angles to the flanges. The latter, both top and bottom, consist of solid or laminated members of stock fir lumber on each side of the web. The flange timbers are glued to the web and at intervals dowels are added to assist in the distribution of the stress. A diagonal timber tension member, which is added at each end of the girders to transfer the tensile stresses from the lower to the upper flange, eliminates the necessity of thickening the webs at the ends of the beams to resist shear. The girders are designed for spans varying from 10 to 60 feet.

This new application of wood for structural purposes has been developed by Timbeam, Inc.

A plate girder with plywood web

Casting's Progress

War Needs Have Intensified the Application of Modern Science and Engineering in Foundry Practice. Now Castings of All Types Have Better Properties, Can Be More Efficiently Manufactured, and are in the Best Competitive Position in Their History

ABOUT the only good effect which wars have on society is the sharp acceleration of technological progress they produce. Thus when we hear of the tremendous strides made in foundry engineering in recent years, it is natural to credit the Martian influence for most of this advance. The wartime transformation of the foundry industry has indeed been considerable, but actually the fundamental changes in foundry practice wrought by the introduction of scientific and engineering methods antedated the war, the latter serving chiefly to spread their influence much more rapidly.

"The foundry industry" is that industry which specializes in the manufacture of castings—metal products made by pouring liquid metal into molds roughly approximating the shape of the finished product. Broadly speaking there are six types of foundries, if classified according to the metals they cast: Gray iron, steel, malleable cast iron, non-ferrous (in the foundry field this term refers to brass and bronze), light metals; and heat- and corrosion-resistant alloy castings.

According to *Penton's Foundry List* there are some 4800 foundries in operation in this country, of which 2890 make gray iron, 600 steel or alloy castings, 126 malleable cast iron, 2620 brass and bronze castings and 2040 aluminum or magnesium castings. In actual weight of delivered castings the gray iron branch of the industry is the colossus, its production being in the neighborhood of 14 million tons annually. Steel castings added up to about two million tons in 1943, "malleable" about one million, and the total of brass, bronze, aluminum, and magnesium about two million.

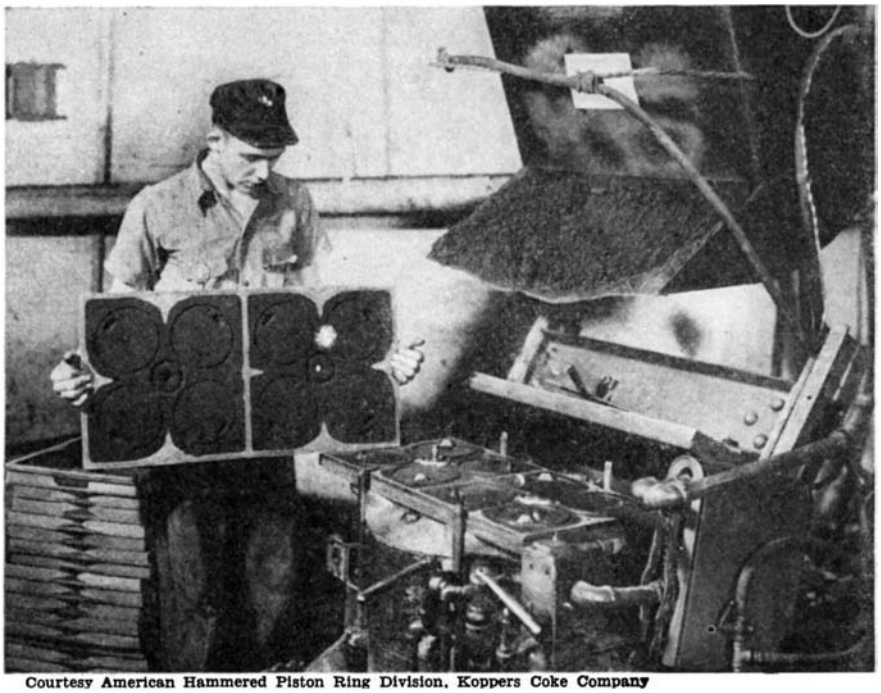
If foundries are backward technically (as is widely believed) then such backwardness is almost a fundamental flaw in our industrial structure. If, however, the foundry industry is progressive (as is actually the case); if it utilizes new scientific concepts and modern engineering practice; and if it has provided its own solid base of forward-looking research and development, then we may expect its influence in the American scene to grow and the market for castings to expand continuously.

Although the products of different foundries may be quite unlike, metallurgically, and tend to find different types of application, the various branches of the industry are strongly bound to each other in the similarity of methods and techniques they employ and in their common marketing problem of presenting the casting as a competitor with forgings, die castings (not usually considered foundry products) welded structures, and other forms.

Because of this, "foundry engineering" today is an actuality and the average foundry is no longer a rule of thumb, by-guess-and-by-gosh, handcraft shop. A frequently remarkable level of product quality and operating efficiency is fast becoming the rule (although the exceptions are still too numerous, in the minds of industry leaders).

RECENT OUTSTANDING ADVANCES in foundry engineering have been in five general directions: (1) the metallurgical improvement of product quality and soundness through the use of modern refining and alloying methods and the application of scientific knowledge of the internal structure of metals; (2) the development and application of specially effective casting processes and molding practices such as centrifugal casting, duplexing and triplexing, plaster molding, directional solidification, and blind risering; (3) the use of "sand control" to improve the surface and internal quality of castings through scientific formulation, treatment, and testing of mold and core sands; (4) the general mechanization of foundry operations, including conveyorized pouring of molds and mechanical handling of sand for conditioning treatment and reclamation; and (5) the employment of the latest quality-control tools — X-ray and radium inspection, the metallographic microscope, pyrometric control instruments for melting and pouring temperatures, spectographic analysis for raw material and finished casting composition control, and so on.

The application of foundry engineering has been well distributed throughout all branches of the field. It is not slighting the others, however, to say that the steel castings and light metal castings manufacturers have embraced modern methods and metallurgy in the greatest proportions. On the other hand, the most notable single trend in the whole foundry field in recent years has been the steady improvement in the engineering quality of gray iron castings



Courtesy American Hammered Piston Ring Division, Koppers Coke Company

Molds made in this pneumatic molding machine have controlled moisture content

made by the average well-managed foundry, and the extraordinary betterment of properties achieved by a smaller number of plants using special processing techniques.

Gray iron is today a material of construction on a par with wrought iron or cast steel for many applications, and superior to it for some. Gray iron is essentially an alloy of iron and more than about 2 percent carbon, with part of the carbon present as graphite flakes. Whereas the average grade of gray cast iron several years ago was called a "weak and inherently brittle material," with a tensile strength of only 15,000 to 25,000 pounds per square inch and few structural or load-bearing applications of importance, today iron of more than 30,000 pounds per square inch tensile strength is common and 50,000-pound iron is the regular product of many foundries.

Although cast iron has a lower ductility than most wrought and some cast materials this fact is of much less importance now than formerly, for the best-informed engineers are today convinced that ductility has been highly over-rated as an essential engineering property, especially for scores of applications involving no tensile loading. But beyond all that, modern gray cast iron offers a unique combination of wear resistance, machinability, capacity for absorbing vibration, and good compressive and tensile strengths that have recently caused many to revise their estimates of its potentialities as an engineering material.

HIGH-STRENGTH IRONS—As evidence of this are many successful wartime applications of high-strength irons for which cast iron would have once been considered quite unsuitable. Diesel engine crankshafts, cutting tool shanks, milling cutter bodies, marine propellers, turbine runners, shell forging dies, rubber-machinery parts, gears and bearings for mobile anti-aircraft guns, hand grenades, and so on, in addition to many machine-tool parts, are now being made as iron castings—some of them specially-processed trade-named irons like Meehanite, Sorbo-Mat, or Proferal, and others unbranded products of equally enlightened foundry practice—and testify to the engineering serviceability of current cast irons.

This steady improvement in strength and quality of gray iron has been achieved through several developments and practices—"inoculation" of the molten iron in the ladle; the use of weighed, dried, or heated air for blowing the hot metal in the cupola; superheating of the molten iron; the incorporation of alloys in the composition to increase strength or hardenability; and the heat treatment (including flame hardening) of cast irons. Many of these practices have stemmed from one basic, only-recently accepted principle: That the properties of cast iron are determined as much by its internal structure, and especially by the size, shape, and distribution of the graphite flakes dispersed in it, as by its composition expressed as total carbon content.

Thus "inoculation" involves the addition to the molten iron of small amounts of calcium-silicide, ferro-silicon, graphite, silicon carbide, silicon-manganese-zirconium, or other agent which cause the graphite to begin forming while the metal is liquid rather than after it has solidified. Thus it produces an ultimately finer and more uniformly distributed graphite-flake dispersion. Superheating and control of cupola air (air-weight control, hot blast, or dry blast) have, among other things, a strong effect on the rate of formation of the graphite and therefore on the structure and properties of the iron.

The incorporation of nickel, chromium, molybdenum, and other metals in gray iron has strengthened and toughened many of today's iron castings or has made them more amenable to heat treatment in heavy sections, so that heat-treated alloy irons may have tensile strengths exceeding 50,000 pounds per square inch. But the demand for these is comparatively small and the gray iron industry's major contribution to ultimate Victory has been its expanded production of high-strength (40,000 to 50,000 pound) irons that contain no critical alloying elements, but which derive their excellent properties from the engineering or metallurgical techniques previously mentioned.

Of all types of foundry products, steel castings have been the most heavily applied in ordnance. For example, the M-4 medium tank, which weighs some 60,000 pounds, contains steel castings to a total of 29,000 pounds, of which 20,000 pounds represents the weight of the one-piece cast armor hull. In fact, the applications of steel castings everywhere in war production have multiplied so rapidly as to necessitate an expansion of the industry from a production level of about one million tons in 1940 to more than two million tons annually at present.

Simultaneously, engineering advances in steel-casting manufacture have come with breathless rapidity. Normally lavish in their use of alloys, steel foundrymen have learned to produce castings of the highest quality with percentages of alloy content formerly considered much too low. Better melting and molding practice, the use of centrifugal casting, and the intelligent application of liquid-quench and temper heat treatments are some of the reasons for that achievement.

Fascinating indeed is the story of centrifugally cast steel and its mushrooming application for products that once could be made only from steel forgings or other wrought products. In centrifugal casting the molten metal is poured into spinning cylindrical molds, which may spin on either a vertical or horizontal axis and may be made of either metal or sand. The centrifugal force of spinning gives the equivalent of a pressure casting, uniformly dense and sound, with inclusions and the unsound portions confined to the easy-to-machine-off inside diameter of the casting.

CAST STEEL USES—The demonstrated high strength, ruggedness, and service reliability of such centrifugally cast steel products as artillery gun barrels, aircraft engine cylinder barrels, automotive brake drums, heavy-duty gears, ship shafts, welding flanges, retort tubes, and so on, have opened new application-possibilities for this still-young metal form, and have given a mental lift to many steel foundrymen who are wondering what post-war use they might make of their war-swollen capacity for producing steel castings.

Steel castings as a product of the "side-blow" converter, once considered of little safe utility for the production of high quality castings, have in the last two years become a regular part of the industry's output. The now-accepted use of the converter followed two stimuli: (1) experimental demonstration by two Batelle Memorial Institute men that converter castings could be every bit as good as those made in the

Courtesy Ford Motor Company

Pouring alloy steel into a centrifugal casting machine

Courtesy Wright Aeronautical Corporation

Making a mold for casting an aluminum cylinder head for an aircraft engine. Long nails are inserted into the sand to act as reinforcements during pouring of the metal

open hearth or electric furnace, and (2) the development of "duplexing" processes whereby the gray iron founder's cupola is used to melt down steel scrap and pig iron, and the carbon, silicon, and manganese are blown out in the converter to produce a satisfactory steel. Such processes not only permitted the rapid production of badly-needed steel castings with only a minor investment in new equipment as compared with the cost of new open hearths or electrics, but also found ready use for many cupolas that would otherwise have stood idle, to the financial embarrassment of their owners.

Refining and alloying of the duplexed metal may conveniently be done in an electric furnace which, when added to the cycle, transforms the process into "triplexing." In addition, the electric furnace frequently serves as a "holding" furnace, acting as a reservoir of hot metal to which molten steel can be added and from which it can be drawn continuously to supply conveyorized molds on a mass-production line.

The application of the so-called "directional solidification" concept has markedly improved the soundness of steel castings and has even permitted the production of castings once thought impossible. Directional solidification involves the controlled speeding of solidification in some regions and the retarding thereof in others through various devices, so that the inevitable shrinkage cavity will occur in the top of a riser (an external, removable appendix to the casting) and not in the casting proper. Allied to this is the very recent expanded use of blind risering or atmospheric-pressure feeding, whereby a sand core (most recently, a graphite wedge) is inserted through the cope of the casting into the top of the riser, which is otherwise enclosed in sand. Hotter feed metal and cleaner, sounder castings are the customary result.

A CHALLENGE MET—Malleable cast iron foundry engineers have met the challenge of war production under extremely trying circumstances, particularly an acute shortage of manpower. The most notable contribution of malleable has been its widespread use to replace highly critical brass or bronze castings or steel forgings in ordnance equipment.

The long annealing cycle in malleable iron manufacture, normally requiring *days* for completion, has been shortened to *hours* in some foundries through the use of a short-cycle practice involving controlled atmosphere furnaces instead of packing the parts in pots filled with solid material. "Pearlitic malleables" (or more accurately "arrested-anneal malleables"), which are short-cycle products combining some of the properties of cast steel and of ordinary malleable, have enjoyed a remarkable increase in wartime application.

The most recent advance in the malleable iron field is the use of tiny amounts of boron (about 0.001 percent) to increase the amenability to annealing of malleable irons containing stray alloy contents introduced via the scrap used in melting.

High mechanization—the use of conveyorized pouring lines and of semi-automatic core-making and shakeout equipment—has been intensively applied in the manufacture of aluminum and magnesium castings. Cast alloy compositions (aluminum-magnesium-zinc alloys, for example) have been developed that require no heat treatment to develop mechanical properties comparable to those of the high temperature precipitation-hardened alloys. The aluminum foundries have learned to make high-grade castings out of secondary metal, and this alone is an achievement of real importance under today's conditions.

The use of plaster-molding processes for making precision castings both in light metals and in brass is finding increasing favor. By means of the process, tolerances approaching those possible with permanent (metal) molds can be achieved, yet without the cost of making metal molds. Applications have been confined to relatively short-run jobs and many have involved conveyorized handling.

The outstanding recent metallurgical developments in brass and bronze castings manufacture have been (1) general realization that the atmosphere in which the metal is melted and refined should be slightly oxidizing *rather than reducing* to promote maximum freedom from porosity and (2) development of secondary metal refining methods and casting metallurgy that permit the use of large amounts of secondary ingot metal (made from scrap) in castings manufacture without significant sacrifice of general engineering quality.

Centrifugal casting and plaster-mold casting have both been applied with striking success for copper alloys and are certain to continue in important use in the post-war period.

Among the broadest trends in the entire foundry field has been the astonishing increase in knowledge of the effect of mold- and core-sand mixture compositions and treatment on the surface finish and internal soundness of all types of castings and the application of that knowledge practically everywhere. Type of sand, moisture content, clay content, and type and amount of binder are all regularly considered in sand formulation. Core-baking temperatures are closely controlled. The use of resin core binders, which require lower baking temperatures and are more readily shaken out, is being endorsed by more and more foundries. Such binders also permit the re-use of core sand without expensive reclamation equipment.

The foundry industry is basic in our industrial economy. It has successfully met the shock of war, continued to improve its technological level and will enter the post-war period better able to meet the competition from wrought products than ever before in its history.

GERMAN ALUMINUM ALLOYS

Have Reduced Copper Use to Vanishing Point

AMONG the closely guarded wartime secrets of America's metallurgical experts are the compositions of two or three new ultra-high-strength, heat-treatable aluminum alloys. Each of the leading aluminum producers has developed at least one and they have been making outstanding contributions to faster, more powerful aircraft.

The Germans haven't been idle, either, in this field. Faced with a copper shortage that makes *our* copper stringency look like super-abundance, the Nazis have sought to eliminate that metal from alloys wherever possible. The most common strong, heat-treatable aluminum alloy **"duralumin"** (17S and 24S in this country) contains 4 percent copper, so German metallurgists have brought forth a new substitute aluminum-base material containing 4.5 percent zinc, 3.5 percent magnesium, and no copper, which is said to be at least the equivalent of duralumin for aircraft construction.

Variations of the alloy in use also contain chromium and manganese for additional strength. Tensile values are over 55,000 pounds per square inch. (The new American alloys give strengths considerably higher than that.) Best results are obtained by a heat treatment comprising heating to 750-925 degrees, Fahrenheit, quenching in water, and allowing to age-harden at room temperature.—*From the German journal "Aluminum."*

PRECISION HARDENING

Made Possible By Use Of High-Temperature Quench

TYPICAL of recent heat-treating developments that have speeded production or assured the maintenance of necessary precision without prohibitive time or expense is the application of isothermal or constant-temperature heat treatment to the hardening of small projectile or other ordnance parts.

(*Continued on page* 134)

Measuring Roughness

When the Motor and Aviation Industries Put Stiffer Demands on Bearings, Something More Scientific had to be Substituted for the Machinist's Eyes and Fingertips. Using Instruments Having a Stylus Point to Draw Across a Surface, the Roughness is Measured in Millionths of an Inch

By HARRY B. SHAPER
The Brush Development Company

ONLY in the past 10 years has the concept of surface roughness obtained a scientific meaning. Various methods of judging surface roughness had been used by the early craftsmen. The fingertips or thumbnail slid gently over a surface are remarkably sensitive to surface irregularities. A trained individual can detect the difference between a perfectly smooth surface and a slightly rough surface whose roughness is below the level reached by optical microscopes. The optical microscope can magnify surface irregularities if they are larger than the wavelength

FIG. 1

Even an irregular surface like this may appear to be shiny and smooth. But the shine comes only from the parts between the irregularities

of the light used, or approximately down to 1/200,000 inch for ultra-violet light. While the fingertips are sensitive, fingertip estimates of roughness still will vary over a range of 10 or even 100 to 1, depending upon different individuals.

A second method of judging roughness was an optical method. Judgment of smoothness was based on the mirror-like quality of a surface. This led to many erroneous estimates of smoothness, since many surfaces which exhibit a dull gray finish may actually have smaller deviations from flatness than one which is shiny and mirror-like. Thus a surface which has been burnished would present to the eye an apparently polished appearance. This type of surface on a piston, as shown in Figure 1, would soon chip and score the walls of the cylinder.

The qualitative methods of judging surfaces—that is, those just described—broke down as soon as the automobile and aviation industries began to search for methods of carrying large loads at high speeds on small light-weight bearings. Automobiles had to be brought from high speeds to a dead stop with small brake drums in a short time. Airplane motors had to develop thousands of horsepower on shafts a few square inches in area. The life of engines at high speed had to be extended. Pistons and rings had to make millions of cycles without developing serious leakage of oil. Cams had to maintain accurate dimensions, to open and close valves in split seconds. For a while it was necessary to break-in engines and mating parts, a process which resulted not only in considerable inconvenience, but in a serious compromise in the permissible fit of parts. Large tolerances had to be allowed during the break-in period so that the mating parts would not freeze together. Consequently, the still larger clearances which existed after break-in resulted in short life due to the extra slap of one rotating part against the other.

QUANTITATIVE PICTURE—The study of the nature of the surface which gave the best over-all performance for load-carrying capacity and long life showed that the roughness of the surface was important. Certain methods of finishing machine parts lead to longer life and shorter break-in periods. A quantitative picture of the nature of the different surfaces resulted in a set of characteristics for an ideal surface. It was found that, in general, for a given machining process:

1. The smoother the surface, the better.
2. Any roughness which existed should be of such a nature that the variations from true flatness should occur as depressions. Figure 2.
3. The surface should not be burnished or spun over in order to attain smoothness, but should be cut away without distorting the grain surface.

The above conditions are not the only conditions for obtaining optimum bearing surfaces, but are the most critical ones. If a surface has all its irregularities below the face, rather than some above and some below a median line, a larger area is available for load support. As shown in Figure 3, even small peaks in the surface can change its bearing properties.

FIG. 2

For load-carrying capacity and long life the variations from flatness should take the form of depressions

A committee on standards has set forth the following definitions for describing a surface:

1. *Lay.* The direction of the machining process. Operations such as grinding, boring, turning, always have two directions at right angles to each other with different micro-inch depth readings. Hand operations, such as lapping and sanding, have no preferred direction of reading. In addition, there are random finishing processes like super-finish, tumbling, and random polishing machines which also have no preferred direction.
2. *Waviness.* The general contour of the finished surface, which is usually of the dimensions of .04 inch or greater.
3. *Roughness.* The microscopic deviations of the surface.

Figure 4 shows the relations of 2 and 3, that is, of waviness and roughness.

The modern methods for measuring surface roughness are:

1. A stylus point rides on the surface in the vertical position and follows the contour of the surface. The deviations of the stylus tip are translated into electrical pulses, and these pulses are magnified and then either read by means of a meter or recorded on a chart to give a picture of the surface. Figure 5 shows a pole shoe and a diamond stylus. Both of these ride on the surface. The respective motions of the shoe and stylus generate electrical voltages. Since the pole shoe follows only the mean height, and the stylus follows the fine deviations, the difference between the two amplitudes, converted into voltages, indicates the roughness of the surface. The pole shoe radius is made small enough so that if the surface is

FIG. 3

Even small peaks in a surface, as is shown in the upper of the contours, can change its bearing properties

absolutely smooth but wavy (waves are considered to be larger than .04 inch) the stylus and the shoe will move synchronously and no voltage will be generated. Therefore the electrical reading is proportional to the roughness alone, and not to the waviness of the surface.

2. Another method of measuring surface roughness is to measure the reflectivity of the surface. A light source is reflected from the finished surface into a photocell. A perfectly smooth surface can be set to give a definite reading; and then, as the surface gets

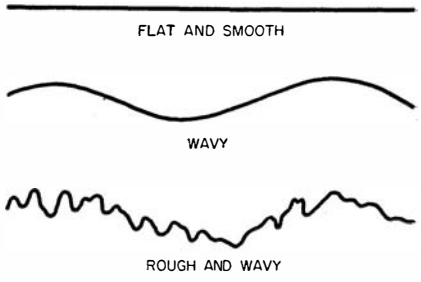


FIG. 4

Waviness and roughness are not synonymous, wavy irregularities being larger. A surface could have a wavy contour without roughness, or a rough contour without waviness

rougher, less light will be reflected into the photocell (Figure 6.) The ratio of these readings is then a measure of the roughness.

3. The taper method: The finished surface is plated. After a heavy plate is put on, the surface to be observed is sliced at a shallow angle, as shown in Figure 7. This shallow angle results in vertical magnification of the surface deviations, but of course gives no horizontal increase. Practical limitations in the grinding and polishing process limit the mechanical magnification afforded by this method to about 25 times. However, once this is accomplished, optical methods of observation become feasible down to fairly small surface deviations, although not as low as the stylus method permits. This method may be used to check the more rapid stylus method. Its very great disadvantage lies in the time required to investigate a surface and in the fact that it destroys the surface.

4. It is possible to measure the roughness of a fine surface in very great detail by using the electron microscope. An extremely thin layer of a suitable drying material is poured over the surface and allowed to dry. This layer is then peeled off, inserted into the field of the electron microscope and photographed. The hills and valleys then photograph respectively in light and dark areas. In spite of the necessary painstaking procedure, this method will be widely used in the future in research to investigate surfaces because of its fineness of detail.

FIG. 5

In the stylus method of measuring surface roughness the stylus is drawn across the surface and its deviations are translated into electrical impulses which are amplified. At the same time a flat shoe traverses the surface and its deviations are separately translated into electrical impulses and amplified. The apparatus then automatically subtracts the small stylus readings from the larger shoe readings, and thus the desired roughness reading is sorted out from the less essential waviness reading

Of the four methods just described, the one used most widely is the stylus point method, and two of this type of instrument are sold commercially. One of them is the "Profilometer" made by the Physicist Research Company and the other the Brush Development Company's "Surface Analyzer" (Figure 8). With these types of instruments, deviations of one micro-inch (millionth inch) can be measured. When it is remembered that the separation between molecules of the material generally is in the order of .005 micro-inch, it is realized that the limit of measurement is pretty close to the ultimate accuracy possible.

Of course, different commercial companies argue for their own method of surface finishing, and the theories developed for the ideal surface are not yet fully substantiated, but all of us have noticed in the past five years a remarkable increase in the life of automobile engines. One of the surface-finishing processes developed is the "super-finish" method used on parts which have been ground down to their prescribed dimensions with fine grinding

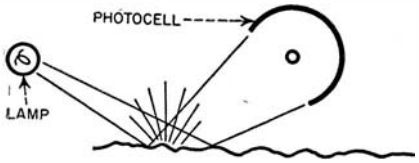


FIG. 6

A simple sketch illustrating the basic principle of the reflectivity method of measuring surface roughness. A perfectly smooth surface would reflect a maximum of the light into the photocell. The light is reflected elsewhere in proportion to irregularities

wheels. These parts are placed in a machine which uses soft and fine stones, flexibly mounted, which scrub the surface slowly and gently for a period varying from 10 seconds to about a minute. This scrubbing action, which is random, serves to cut away gently the sharp edges protruding from the surface, leaving only valleys in the material.

With this super-finish process, tolerances of the finished parts are maintained very closely, and only a small amount of break-in is required. The depressions serve, in addition, to retain oil where oil is used between the mating parts.

The proponents of this finish have run some experiments showing that the rust-resisting properties of these finished parts on exposure are superior to those

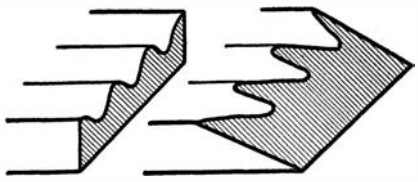


FIG. 7

Illustrating the taper method of measuring surface roughness. Slicing the surface diagonally, as shown, magnifies the irregularities vertically

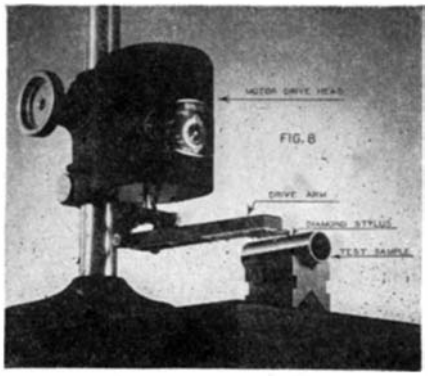
of other finely finished surfaces. This is understandable when we remember that, by finishing a surface to a great degree of flatness, the total area is actually decreased even though the bearing area is increased, and in addition the surface has no sharp corners where electrolytic action can occur with greater intensity.

As in the super-finish process, it has been found that, by taking a finely finished surface and gently sanding it with very fine sandpaper, the load bearing capacity of the material will rise two or three times, due to the increase in surface contact area.

In general, then, the reason for investigating the finish of a surface depends upon the fact that when two parts meet in a bearing or other working machine part, the largest area of contact possible will generally result in better performance. The reason for the use of soft bearing materials on one of the mating parts is that the soft material tends to fill the crevices in the hard material, and then the two parts mate more smoothly. The disadvantage of using a soft material, such as a Babbitt metal, is that the metal cannot support heavy loads without distorting.

OPTIMUM COMPROMISE—The requirement that all surfaces be finished to small micro-inch readings is complicated as soon as design and production cost come into the engineer's consideration. For example, when considering the design of automobile brake drums there is a choice between making the finish finer and making the shoe larger. Making the drum larger so that it can conduct a given amount of heat generated requires space and weight. This results in higher material cost and a lower machining cost. Finishing the

(*Please turn to page* 135)



The Brush Surface Analyzer. Its motor-driven arm slides the stylus and shoe steadily across the surface

Keeping Business In Business

One of the Outstanding Stories of Materials Substitution to Grow Out of Metal Shortages is that of the Use of Fabricated Fiberboard for a Wide Variety of Applications. Refrigerators, Clothes Lockers, Lunch Boxes, Lighting Reflectors, and Toys are Only a Few of the Items Affected

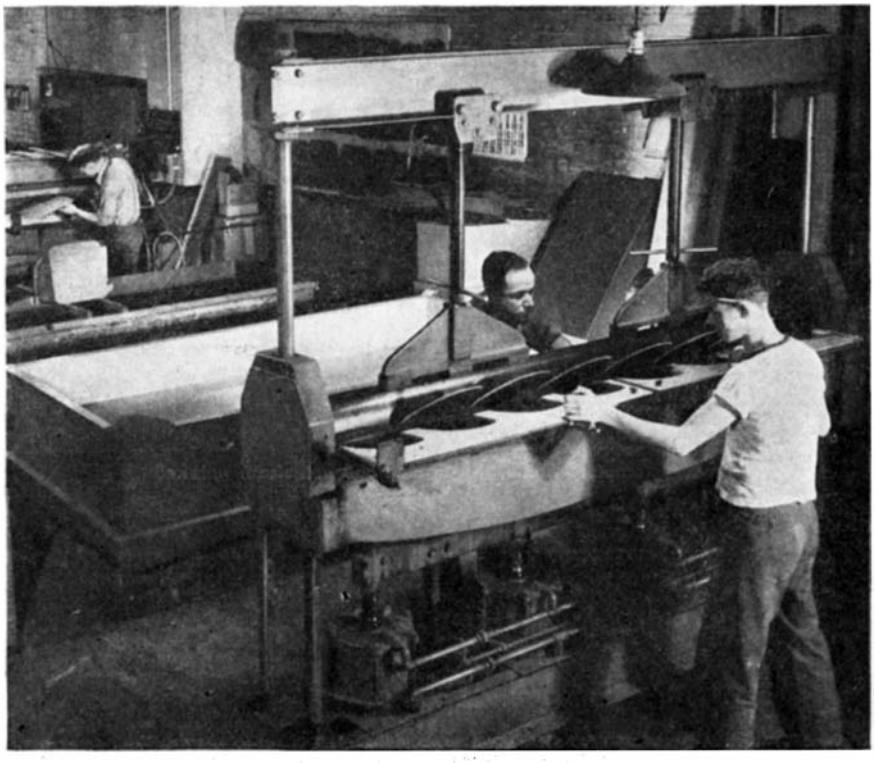
By A. P. PECK

DRASTIC orders which the War Production Board issued, curtailing the use of critical metals—steel, copper, aluminum, and various alloys—in the manufacture of civilian products, threatened to put innumerable companies, both large and small, entirely out of business. That many of these companies have survived and are now thriving, is the basis of a fascinating story of scientifically applied substitutions. While these substitutions have been carried out in many ingenious ways, one of the outstanding examples is the use of fabricated fiberboard as a replacement material for formerly used metals. In many cases where fiberboard has been so applied, it was found that production could be speeded up, often with savings in the final weight of the finished item and, in many instances, substantial savings in cost.

Essentially the secret of the properties of fabricated fiberboard of the Masonite type lies in the two basic elements of natural wood: The tiny cellulose fibers of which wood is composed and the lignin which holds them together. From this natural material, through a process of "exploding" the wood, it is possible to produce a hard, strong board which lends itself admirably to a wide variety of uses in many fields.

When the wood is "exploded," the cellulose fibers are not damaged nor is the lignin removed. The "explosion" results in a mass of fibers of varying degrees of plasticity, which can then be interlaced and, under varying degrees of heat and pressure, be "welded" together into a board which shows properties of equal strength in all directions. In this process the lignin itself furnishes the bond.

From the fiberboard so produced it is possible to fabricate shapes of various contours, applicable to the production of a number of different manufactured units. Many such applications have been made and so successful have they been that it is probable many of them will continue in use after metals, in which the situation is even now easing, are once more available to industry in general.



Bending fabricated fiberboard to specified contours

A few examples of the uses to which fabricated fiberboard has been put will serve to indicate the possibilities of this material and perhaps to project a trend of the future.

A steel refrigerator manufacturer was formerly using approximately 100 pounds of metal per unit produced. Today, however, restrictions dictate the use of a maximum of six pounds of steel per unit; fiberboard has been applied to make this enormous reduction possible. By fabricating the sheets to the desired sizes and contours and providing baked surface finishes, a refrigerator is now being produced which is stated to have all the glowing beauty and durability of the former models combined with the essential sanitary qualities necessary in refrigerators.

When expansion of war plants called for an unprecedented production of lockers for the workers, a complete line of fiberboard lockers, wardrobes, and storage cabinets, were designed, using a minimum of critical materials. These overcome the objections to ordinary wood lockers because they provide fire protection, are resistant to moisture, have high strength and durability, permit flexible rearrangement and use with steel lockers that may already have been installed, and resist the absorption of food and other odors.

METHODS PERFECTED—Active in the work of fabricating Masonite has been Service Industries, Inc., who have perfected methods of handling and bending the material. One of the examples of work done by this organization has been the production of reflectors for fluorescent lighting. Good lighting is an essential in all types of industrial production, yet until only a short time ago metallic reflectors were considered essential to

such installations. And upon the contour and efficiency of a reflector depends largely the overall efficiency of a lighting system.

Starting with a maze of highly technical lighting problems, reflectors were designed to be fabricated entirely from fiberboard. In the course of this work a special plastic-impregnated board was developed. Now, as a result of concentrated research, standardized fiberboard reflectors have the approval of the Underwriters' Laboratory, the War Production Board, and the Electrical Testing Laboratories. Some manufacturers are guaranteeing 85 percent efficiency for these reflectors, with actual efficiencies ranging up to as high as 89 percent. These efficiencies are considerably higher than those of porcelain-enamel reflectors.

Fiberboard reflectors for fluorescent lighting

In lighting fixtures of this type, efficiency of a reflector is not the whole story. Fiberboard reflectors show great savings in weight. The 40-watt fiberboard reflector weighs only five and one half pounds, the 100-watt reflector only ten pounds; whereas metallic reflectors of similar size weigh two to three times as much. Then too, the fiberboard is non-corrosive, retains its shape because of its rigidity and will not dent or kink as will metal.

In the field of blades for fans used for cooling and other purposes in industry, thousands of pounds of metal were formerly used. Now blades are being made of fabricated fiberboard with efficiencies equal to those of metal blades. Furthermore, some people think that fiberboard fan blades are quieter in operation. Certain it is that many manufacturers who are using these new fan blades have found so many advantages in them that they will never return to the use of metal.

Steel wheels for baby carriages was another item hard hit by the restrictions on metals. Something had to be found to replace the steel and it had to be tough as well as resistant to rain, sleet, snow, heat and cold, and the shock of rolling over rough pavements. The problem was solved by producing wheels composed of three laminations of fiberboard, machined and grooved for tires and axles. In the first few months of production more than 200,000 of these wheels were put into service. So far there have been less than half a dozen replacements, indicating that fiberboard wheels will outlast steel wheels many times over. Furthermore, the fiberboard does not require greasing and will not squeak even after long use. It is estimated that through the adoption of this laminated wheel approximately 180,000 pounds of steel have been released in one year of production.

The poultry industry was thrown into a sorry predicament when steel for the manufacture of chick brooders, nests, and feeders was restricted. The industry was being called upon to increase its production, yet the use of steel for vitally needed units was virtually prohibited. Into this picture stepped fabricated fiberboard to produce laying nests, brooders, and feeders that are not only satisfactory to poultry raisers but appear to be well liked by the hens themselves. It has been shown that the hens prefer fiberboard, probably because it is warmer in winter and cooler in summer.

Another item for which there has been a tremendously increased demand by war workers is the lowly lunch box, formerly made entirely of metal. The newest lunchbox, however, is made almost entirely of fabricated fiberboard, except for the metal hinges and latch, with a plastic handle and waxed paper insert lining at the bottom of the box. It is made to fit a pint size vacuum bottle, weighs about two pounds, and can take an enormous amount of abuse.

DESIRABLE QUALITIES—To these and many other manufactured products, fiberboards such as Masonite and Tempered Presdwood have brought the desirable qualities of hard surfaces im-

Fiberboard has largely replaced metal in this refrigerator

A lunch box that uses metal only in hinges and latch

The desk lamp and correspondence boxes are fabricated of fiberboard

pervious to ordinary liquids, durability for years of wear, and resistance to chipping or cracking under impact.

The recitation of details could be extended almost indefinitely, but many of them would be repetitious of what has already been recounted. The civilian products fabricated wholly or largely from fiberboard now include, among others, such diversified items as desk lamps, children's toys, clipboards and filing equipment for offices, starch trays for the candy industry, fire-resistant stove boards to protect floors under domestic space heaters, card tables, ironing-board tops, kick and push plates for doors, and so on.

But civilian production has not been the only beneficiary of this work toward perfection of fiberboard as a replacement material. Similar applications have been made in war industries, notable among them being the use of the board for bench tops, production-line trays, bench bins, and the like.

Thus American ingenuity has come to the rescue of industry with a material and methods of fabrication which not only have served to contribute directly to stepping up war production in defense plants but have also helped many manufacturers to stay in business without a drain on critical materials.

RECENT notices in the daily press have contained statements to the effect that Scientific American is collaborating in an offer of $10,000 to be paid in connection with demonstrations of physical psychic phemomena. Scientific American has no connection with such offer. When our recent investigation of psychic matters ended, as announced in our issue of April 1943, our monetary offer was withdrawn and we now are taking no active part in any matter of this character.

INDUSTRIAL GOLD

Uses May Expand If Price Drops

TODAY'S upheavals may demonetize gold and release more of the metal for industrial and ornamental use. The world's annual gold production is a little over 1000 tons of which 900 to 950 tons are immediately reburied in governmental treasuries, which now hold some 30,000 tons. With government price support withdrawn, the price should fall sharply, and with it production, but the amount then economically usable by industry might be far larger.

Gold is too scarce ever to be cheap; its industrial use must be based on its unusual properties. Although gold is dissolved by aqua regia (a mixture of nitric and hydrochloric acids), it resists all other chemical agents except elementary chlorine and fluorine, by which it is slowly attacked. It is the most malleable and ductile of all substances; one ounce can be beaten into 250 square feet of gold leaf. Particularly important is the fact that it can be fired firmly onto porcelain, glass, and so on to form a fast joint. Another unusual property is ability to weld to itself and to other metals at ordinary temperatures by pressure alone. Finally, gold is one of the easiest metals to heat, cool, or melt, in terms of heat required.

Present industrial uses of gold include gold-platinum alloys for viscose rayon spinnerets; gold-palladium-iridium-platinum alloys in thermocouples designed for extremely accurate temperature measurement; and such therapeutic applications, in addition to dental work, as use of gold-silver alloy plates for repair of skull injuries, permanent insertion of gold capsules containing radioactive substances in malignant neoplasms, and the treatment of arthritis and tuberculosis with gold salts. Electrical equipment for measuring aircraft speeds includes a tiny motor generator with 15-karat gold wire in the generator brushes.

Gold has long been applied to the surfaces of less noble materials by gilding, plating, application of gold leaf, or rolling. The last method consists of soldering or welding a plate of gold onto a block of another metal and then rolling out the covered block to the required thickness, giving a sheet consisting of base metal uniformly faced with gold. An appreciable quantity of gold is used for decoration of pottery, porcelain, and glass in the form of "Liquid Gold," a brownish solution of complex organic gold compounds in essential oils, containing adhesive materials. It is brushed on the ceramic object and, after firing, the pure metal remains as an extremely thin, lustrous surface layer. A recent development in the plating field involves electrically heating gold to its melting point in a high vacuum, the gold falling in a molecular film upon the article placed in the evacuated chamber.—*Industrial Bulletin* of Arthur D. Little, Inc.

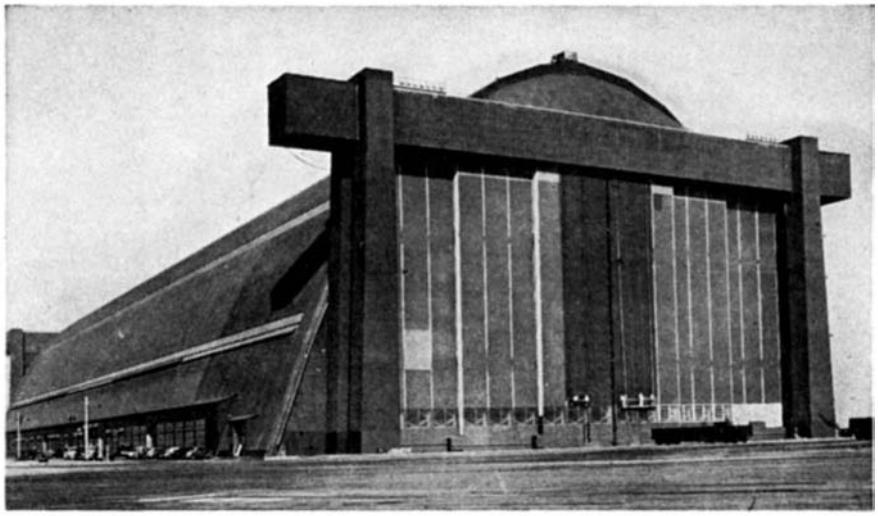
FLAMEPROOFED PLYWOOD

Treated a Carload at a Time by New Process

PLYWOOD'S only serious disadvantage, inflammability, is now being removed by a flameproofing process which gives the material the same fire resistance as the flameproofed timber used in the Navy's new all-wood blimp hangars.

Sheets of plywood are now being flameproofed, a carload at a time, by American Lumber and Treating Company's Minalith process. This pressure treatment employs a combination of phosphate, sulfate, and boron chemicals. Ordinary untreated plywoods burn like untreated timber; with some glues, heat causes delamination of the plies, aggravating the fire hazard. The new treating process, however, prevents flame spread and delamination by filling the wood cells throughout the plies with chemicals which inhibit the flaming characteristics of wood substance.

A procedure followed in flameproofing plywood doors for a West Coast blimp hangar sets a pattern for fire-retardant treatment. The plywood was first fabricated, then impregnated under vacuum pressure in heavy steel cylinders, and thoroughly dried after treatment. The plywood sheets were then given two coats of paint before



Doors of this blimp hangar are made up of flameproofed plywood panels

GREATER...EVER GREATER...GROWS

Zenith's Crusade to Lower the Cost of Hearing!

NEW ZENITH RADIONIC HEARING AID...

Another Zenith "First"!

LIKE A TIDAL WAVE, the success of this fine radionic instrument that opens the world of sound to millions is sweeping across the nation!

Again Zenith, world's leading manufacturer of radionic products exclusively, has scored a "first" of historic importance. Truly, it is the spearhead of a mighty Crusade... to rehabilitate new thousands of men and women for vital wartime work... to save children from lives of failure and misunderstanding... to bring new happiness to the hard of hearing, their families and friends.

America is entitled to know that Zenith, through this Crusade, has brought about a *revolution* in the cost of good hearing, as evidenced by the tremendous public demand. Zenith has been deluged beyond all anticipation! We are increasing our production daily, but Zenith will never sacrifice quality for quantity. The hard of hearing have waited years for this Crusade. We ask them to be patient a little longer, until Zenith production can supply the demand in all areas of the nation.

Meanwhile, you are invited to attend the demonstration now going on at your local optical establishment franchised by Zenith. Let your ears decide—you will not be pressed to buy. No salesman will call at your home. Send for our free descriptive booklet. The coupon below is for your convenience.

Accepted by American Medical Association Council on Physical Therapy

$40.00 READY TO WEAR

Complete with Radionic Tubes, Crystal Microphone, Magnetic Earphone and Batteries, and covered by a liberal guarantee. . . . No extras. No "decoys." **One model — One price — One quality.**

To Physicians:

A detailed scientific description will be sent upon request. Further technical details will appear in medical journals.

There are cases in which deficient hearing is caused by a progressive disease and any hearing aid may do harm by giving a false sense of security. Therefore, we recommend that you consult your otologist or ear doctor to make sure that your hearing deficiency is the type that can be benefited by the use of a hearing aid.

Only Zenith Gives You:

1 **The fine precision quality that modern knowledge and engineering make possible in a hearing aid . . . yet priced at only $40,** complete, ready to wear. No extras, no "decoys." One model, one price, one quality. You need not pay more or accept less.

2 **Four-Position Tone Control.** The flick of your finger instantly adjusts it to right combination of low, medium and high tones for individual needs in varying surroundings, hearing deficiencies in any range. No further adjustments necessary.

3 **Special Battery-Saver Circuit.** Insures low battery consumption . . . makes batteries last up to three times as long.

4 **Zenith Quality, Zenith Guarantee.** Zenith, world's leading manufacturer of radionic products exclusively, is fortunate in having the precision production facilities to supply this quality hearing aid in quantities that make possible its low price. Guaranteed for a full year, with unique service insurance plan for life.

These and many other advantages combine to make this hearing aid revolutionary—not only in first cost, but in low upkeep cost and excellence of performance.

BY THE MAKERS OF

ZENITH *LONG DISTANCE* RADIO

RADIONIC PRODUCTS EXCLUSIVELY—WORLD'S LEADING MANUFACTURER

Mail Coupon for Free Descriptive Booklet

ZENITH RADIO CORPORATION, DEPT. SA-3
P. O. Box 6940 A, Chicago 1, Ill.
Please send me your FREE descriptive booklet on the New Zenith Radionic Hearing Aid.

*Name*_____

*Address*_____

*City*_____ *State*_____

erection, followed by a camouflage paint application after they were set in place.

Plywood sheets are sanded after treatment if they are to be used in natural grain-finish panels. If sheets are to be used in painted units, no sanding is required.

With fire resistance added to its other well known characteristics, plywood may become an outstanding material in post-war construction. Strongest material for its weight, plywood has the stiffness needed in large panels. It need not be drilled for nailing, it has measurable insulating properties, is virtually unaffected by temperature changes, and can be glued as well as fastened by ordinary means.

POTATO PLASTICS

Offer Possibility of Using Agricultural Wastes

FARM WASTES and their potential uses in industry is a subject which has come rapidly to the foreground, forming a basis for considerable research and study. The installation of three white-potato starch plants producing approximately 13 million pounds of starch from cull potatoes annually, and the operation of ten vegetable dehydrating plants in southern Idaho, have together resulted in the production of immense tonnages of waste material, thereby making the consideration of waste disposal a timely topic for chemurgic research.

Anticipating the problem, the Idaho committee of the National Farm Chemurgic Council laid its plans a year ago for research. The disposal of over four million pounds of potato pulp remaining after starch extraction posed the first question to which an answer is being sought. The pulp has some value as a stock feed in both the wet and dry forms, but research men became interested in the possibility of making plastics from it.

Preliminary investigations demonstrated that the residue remaining from the potato starch making operation in its natural form, if properly handled, would plasticize when subjected to heat and pressure. The plastic so produced was limited as to flow and water characteristics.

Research chemists at the College of Idaho went to work for the Committee on the problem of improving these characteristics. Their efforts have resulted in a marked improvement in the molding powder and plastic articles which are now produced. Tests show moisture absorption within limits suitable for many commercial uses, and flow characteristics are suitable for the molding of many articles. Shrinkage can be controlled and appears to be within acceptable limits. Metal inserts cast into the plastic remain firmly imbedded and withstand the usual tests for this use.

Belt pulleys of the "V" groove type have been made from the potato pulp, and also with sweet clover fiber added. These pulleys are found to be satisfactory for driving fans, air compressors, and so on. Sample license plates have been made from the potato plastic and submitted to the State of Idaho as a possible substitute for metal license plates.—*Ralph E. Gale, in The Chemurgic Digest.*

PAINT MEASUREMENTS

Made by Two New Testing Machines

THE DEVELOPMENT of two new machines for controlled testing, measurement, and evaluation of the flexibility, scratch hardness, and adhesion of paints and other coatings, was announced recently by The Arco Company, manufacturers of industrial, automotive, and special infra-red camouflage paints.

Tests and measurements of flexibility are made on a machine known as the Elongage. This has been developed around a conventional Erichsen sheet-metal testing machine, which was adapted to provide complete automatic controls and accurate measurements for cycle testing. The machine is mounted with its observation well in a vertical position so that water from a hypodermic syringe is in contact with the paint film being tested. Two wires, one of which is attached to the test panel and the other to the hypodermic needle, are connected to a galvonometer.

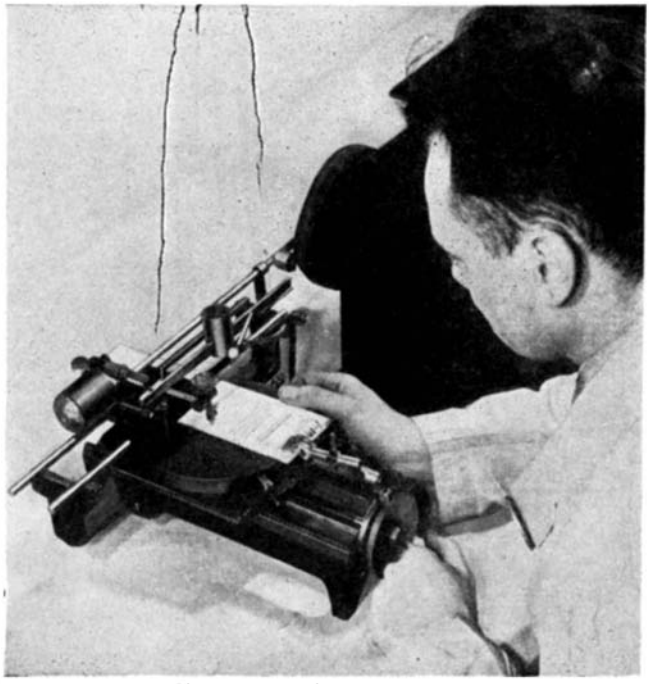
The machine is operated by a constant-speed drive geared to thrust a 3/16-inch spindle against the back of the test panel which is clamped between two anvils. The paint film being tested acts as an insulator. When it fails, the water contacts the steel test panel and a current flows. This deflects the galvonometer meter which signals the end point of the test.

The thrust is measured in 1/100mm and is converted to percentage of elongation by a fixed table. In this way the points at which failures occur on identical panels after various degrees of exposure can be accurately measured, recorded, and compared.

Scratch hardness and adhesion are measured by the Microknife. This consists of a diamond-point cutting tool which is applied to the surface being tested by a lever arrangement carrying beam and weight. The load, measured in grams, is applied to the point, which moves across the surface at a constant speed and cuts repeatedly in a fixed position until the sub-surface is revealed. The load on the beam and the number of strokes required to wear through the film are the measure of scratch hardness. The diamond-point tool is rotated at each stroke to maintain constant sharpness over long periods.

Used in connection with a movable platform which can be adjusted laterally by a precise screw thread and notched wheel, the Microknife becomes an accurate adhesion measuring machine. Tests are accomplished by applying a

Testing paint-film flexibility with the Elongage, described in the text. The panel under test may be seen in the device



Using the Microknife for checking scratch hardness and adhesion of paint films. Note the diamond-point cutting tool

Never mind "who done it"—pitch in and help get it down!

THIS IS YOUR UNCLE SAM talking—but I'm going to talk to you like a DUTCH uncle, to keep all of us from going broke.

Ever since the Axis hauled off and hit us when we weren't looking, prices have been nudging upwards. Not rising awfully fast, but RISING.

Most folks, having an average share of common sense, know rising prices are BAD for them and BAD for the country. So there's been a lot of finger pointing and hollering for the OTHER FELLOW to do something—QUICK.

The government's been yelled at, too. "DOGGONNIT," folks have said, "WHY doesn't the government keep prices down?"

Well, the government's done a lot. That's what price ceilings and wage controls are for—to keep prices down. Rationing helps, too.

But let me tell you this—we're *never* going to keep prices down just by leaning on the government and yelling for the OTHER FELLOW to mend his ways.

We've ALL got to help—EVERY LAST ONE OF US.

Sit down for a minute and think things over. Why are most people making more money today? It's because of the SAME cussed war that's killing and maiming some of the finest young folks this country ever produced.

So if anyone uses his extra money to buy things he's in no particular need of . . . if he bids against his neighbor for stuff that's hard to get and pushes prices up . . . well, sir, he's a WAR PROFITEER. That's an ugly name—but there's just no other name for it.

Now, if I know Americans, we're not going to do that kind of thing, once we've got our FACTS straight.

All right, then. Here are the seven rules we've got to follow as GOSPEL from now until this war is over. Not some of them—ALL of them. Not some of us—ALL OF US, farmers, businessmen, laborers, white-collar workers!

Buy only what you need. A patch on your pants is a badge of honor these days.

Keep your OWN prices DOWN. Don't ask higher prices—for your own labor, your own services, or goods you sell. Resist all pressure to force YOUR prices up!

Never pay a penny more than the ceiling price for ANYTHING. Don't buy rationed goods without giving up the right amount of coupons.

Pay your taxes willingly, no matter how stiff they get. This war's got to be paid for and *taxes are the cheapest way to do it.*

Pay off your old debts. Don't make any new ones.

Start a savings account and make regular deposits. Buy and keep up life insurance.

Buy War Bonds and hold on to them. Buy them with dimes and dollars it HURTS like blazes to do without.

Start making these sacrifices now—keep them up for the duration—and this country of ours will be sitting pretty after the war . . . *and so will you.*

Uncle Sam

KEEP PRICES DOWN!

Use it up • Wear it out
Make it do • Or do without

This advertisement, prepared by the War Advertising Council, is contributed by this magazine in co-operation with the Magazine Publishers of America.

standard stress at progressively smaller spacings until the stress is sufficient to displace the coating in the area between cuts. By this means it is possible to measure the relative adhesion of a given coating to various base metals and sub-coatings, as well as to record changes in adhesion caused by aging of the paint under various conditions.

GAS TURBINES

Feature Simplicity, Still Lacking in Efficiency

THE GAS turbine offers a near-ultimate in operational simplicity. Now rather widely used to convert waste, hot, combustion gases to useful power, the few prime-mover installations suggest it for large-capacity applications, as in driving large electric generators. If it could be adapted to small units, a true revolution in power generation might result.

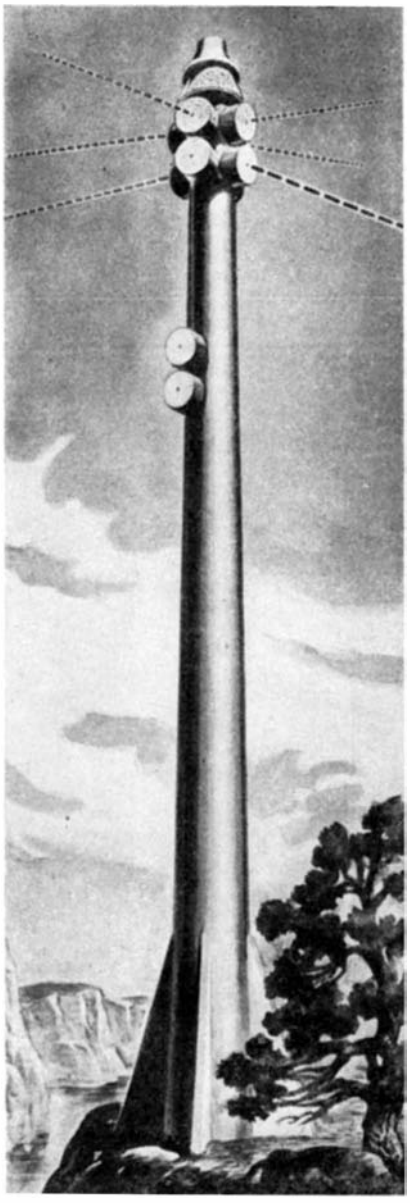
The reciprocating steam engine is a complex, inefficient mechanism requiring an auxiliary steam-generator plant. The more efficient steam turbine reduces the complexity but retains the steam plant, while the gasoline engine and the Diesel, with still greater efficiency, eliminate steam but greatly increase the mechanical complexity. Each of these has found its place, the gasoline engine in light automobiles and aircraft, the Diesel for heavier transportation equipment and stationary power generation, and the steam turbine for the largest units, such as ships and various kinds of central-station electric generators.

Competition continues. The steam locomotive, a reciprocating machine of 8 to 12 percent efficiency, burns the same total weight of fuel as does the automobile in the United States. It is being replaced now by the Diesel-electric, more complex and burning a more expensive fuel, but 20 to 25 percent efficient. The gasoline engine burning 100-octane fuel can achieve efficiencies of about 35 percent, but the extreme complexity of that engine and the high unit cost of the fuel limit it to the various applications where weight saving in engine and fuel load is of the greatest importance.

The efficiency of the gasoline engine would be hard to match, but the gas turbine can outdo it and all other prime movers in simplicity, for it eliminates the steam turbine's steam-producing and condensing system, the gasoline engine's cooling system, and the problem of lubricating hot, sliding surfaces. This turbine is simply a special sort of enclosed multiple windmill driven at high speed by a hot wind produced by burning a fuel in a stream of air. The wind may be produced especially for the purpose or may occur incidentally to another process, as in the use of aircraft engine exhaust gases to run turbo-superchargers (simple gas turbines), which compress thin, high-altitude air for the aircraft engine, or in the recovery of power from the burning of deposited carbon from catalysts used in gasoline production. The "by-product" applications are recent innovations and are contributing much to the development of the gas turbine; however, its future as a primary power generator is yet to be determined.

A British patent on a crude gas turbine was issued near the end of the 18th Century. Then, as now, the objective was to eliminate the steam plants, condensers, and so on, and to produce rotary power without the intermediary of cranks, connecting rods, pistons, and so on. And then, as now, the usefulness of the device was limited by its poor adaptation to small units and the difficulty of finding metals to withstand the temperature of the combustion gases. The manufacture of small gas turbines would still require impractically high precision (an insignificant power "leak" of a given size in a large unit becomes of dominant importance in a small unit), but the usefulness of large power units has increased greatly since the 18th Century and metallurgical advances have raised the permissible operating temperature to practical levels.

A Swiss oil-burning gas-turbine locomotive built just before the war with the materials then available was reported to show an overall efficiency of 15 to 18 percent, comparing with 8 to 12 percent for a steam locomotive and about 28 percent for a good stationary steam turbine. In the gas turbine an air compressor attached directly to the turbine shaft forces in the air needed for combustion, and in some models forces in considerable excess air to pre-



Artist's conception of how a television relay station of the future may appear. Signals will be beamed

vent the combustion gases from raising the operating temperature too high. In a recently developed arrangement of two gas turbines, the excess air going through the first is used for combustion in the second, where the inert combustion products of the first keep the temperature down, thus reportedly raising the efficiency to some 23 percent at the same operating temperature.

As with any heat engine, the efficiency of the gas turbine rises markedly as the operating temperature is increased. Thus a turbine efficiency of 18 percent at 1000 degrees, Fahrenheit, rises to 23 at 1200 degrees, Fahrenheit, apparently the top limit of the forged alloy steel rotor blades used in existing gas turbines. Precision casting methods developed for making the rotor blades for airplane turbo-superchargers from new, non-machineable, non-ferrous metals permit a temperature of 1500 degrees, Fahrenheit, and perhaps higher, with a wholly disproportionate gain in efficiency.

The manufacture of a small turbine, say of automobile size, is difficult, but not impossible. In larger sizes, designs for airplane turbine engines have been proposed in Switzerland, although none has been reported used in flight, and present ratios of weight to horsepower seem unfavorable.—*Industrial Bulletin* of Arthur D. Little, Inc.

RADIO RELAYS

Promise Farflung Television Networks After the War

NATION-WIDE television networks made possible by automatic radio relay stations, and other new developments which eventually are expected to lead to finding the key to international television, are a post-war prospect, according to Ralph R. Beal, Research Director of RCA Laboratories.

A radically new form of "lighthouse" radio relay station will make relaying of television programs a relatively simple matter, according to Mr. Beal. He envisages that these unattended relay stations, located 20 to 50 miles apart, will not only link television stations into national networks but will open up a new era in international communications, through development of trunk lines over such vast areas as Russia and China.

"It is to be expected," says Mr. Beal, "that television stations will first go on the air in such broadcasting centers as New York, Chicago, and Los Angeles. But there is every indication that alert broadcasters will keep pace with them in such localities as Boston, Philadelphia, Washington, Pittsburgh, Cleveland, Detroit, St. Louis, Kansas City, Omaha, Denver, and San Francisco. It seems logical to assume that the first television network linked by radio relay stations will be formed along the Atlantic Seaboard.

"But television will not be limited to the larger cities. The radio map will be dotted with stations in cities like Schenectady, Utica, Syracuse, Minneapolis, Erie, Buffalo, Louisville, and many others. By the use of radio relays, these too will become outlets for the television network which before many years pass after the war, will weave from the east across the Mississippi and the mid-west plains to meet a Pacific Coast link striking eastward across the Rockies. A relay station atop Pike's Peak might well be the key station to complete a transcontinental television chain."

Radio relaying will be a comparatively simple process, Mr. Beal explains. The relay transmitters will operate on microwaves with the energy concentrated almost in a bee line. Practically all the power is made to serve a useful purpose; it is not scattered as in broadcasting. Therefore, relatively small amounts of power will operate the relay transmitters. The apparatus is neither cumbersome nor complicated. It is simple and compact. It could not be otherwise and still perform in the domain of tiny wavelengths which bring radio men so close to the frontiers of light.

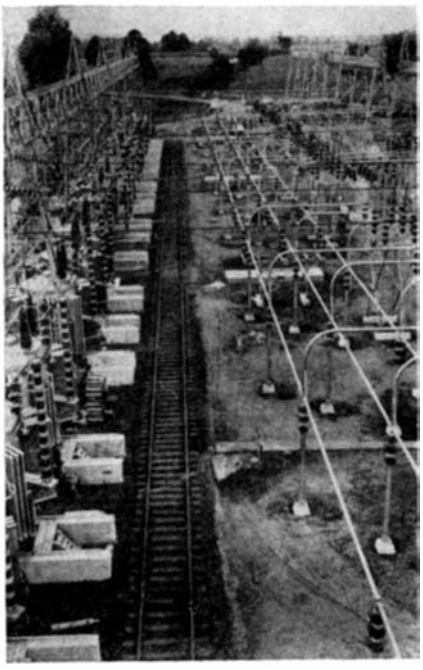
"We know, of course," continues Mr. Beal, "that ultra-short waves travel in a straight line and leave the earth on a tangent at the horizon. The area of the earth's surface touched by such waves is much like that touched by a stick held against a basketball. Obviously, if we use high towers or antennas on lofty buildings or mountain peaks, we capture and re-transmit the waves at higher levels, and therefore their effective range is lengthened. With the use of radio relay stations, the average range is about 30 miles, depending upon the terrain and various other factors. It is interesting to recall that an airplane over Washington, D. C., carrying a television receiver, intercepted the pictures from the NBC aerial on the dome of the Empire State Building 200 miles away. But for such long distance reception of the ultra-short waves, the plane had to go up 20,000 feet."

IRON PIPE BUSES

Find Satisfactory Use in Large Power Plant

ENGINEERS of the Bonneville Power Administration in Washington have put wrought iron to work as a capable substitute for war-scarce copper and aluminum electrical buses. This is reported to be the first recorded instance in which this metal has been used for such current-carrying mains and, according to J. A. Gerber, assistant engineer at Bonneville, "wrought iron need not be classified as an 'ersatz' material; there are many points in favor of using it for permanent buses."

Determination of the ability of wrought iron pipe to serve for these buses is expected to eliminate further need of borrowing for this use from the government's buried horde of silver. The Treasury Department has been releasing silver to replace copper, aluminum, and tin to needy war industries. Already a half-billion dollars worth (700,000,000 ounces) has been distributed under



First recorded installation of welded wrought-iron electrical buses

congressional permission and War Production Board allocation, but must be returned within five years.

The current-carrying capacity of wrought iron pipe is ample for the Bonneville job, the largest size required being four-inch I. P. S. standard weight. The capacity may be further increased, if necessary, by slotting the pipe along its length to break the ferrous loop, and by coating the pipe with a dull black paint to increase the heat emissivity.

Wrought iron has a high modulus of elasticity, permitting long spans, particularly with ice and wind loading, thus saving on insulators, fittings, and supports. It has good corrosion-resisting properties, while paint gives additional protection and is easy to apply.

Welding is an easy, quick, and economical way of joining the pipe into whatever bus arrangement is desired. All clamp type fittings are eliminated, since welding produces joints that have high electrical efficiency as well as permanence. Since the pipe expands less than copper or aluminum, fewer expansion joints are required.

STEEL WIRE
Replaces Copper in Transmission Lines

ANOTHER development in the replacement of copper for electrical purposes is found in transmission wires which are now being made entirely from steel. While copper is a better conductor of electricity than is steel, it does not have the strength which permits spanning long distances. Poles or other means of support have to be spaced at comparatively short intervals because the weight of the wire itself, together with the added weight of ice or snow accumulations, would cause breakage in long spans.

American Steel and Wire Company engineers pioneered in the partial use of steel in transmission wires, permitting advantage to be taken of steel's superior strength. The first step was to provide one strand of steel twisted with two strands of copper, the former providing strength and the latter conductivity. The next development was to compound two strands of steel with one of copper, resulting in still greater strength. An obvious logical step might have been to produce a combination of one strand of steel and one strand of copper, but it had been found that such a construction was not practicable; when it is exposed to a wind running parallel to the conductor, such two-strand wire develops an oscillating propeller motion which results in early failure. Much experimentation was engaged in before a suitable all-steel wire with relatively high electrical conductivity was developed.

While the new wire is not designed entirely to replace copper transmission lines, definite advantages are afforded in specific applications such as providing a means of transmitting electric power economically to isolated rural areas or industrial installations. The production of the steel wire is carefully controlled throughout all stages of manufacture. Especial care is necessary in selecting raw materials and extremely high control is maintained in making the steel, rolling the rod, and drawing the wire. A heavy coating of zinc is applied for corrosion resistance. The result is a quality product with a high tensile strength and fatigue resistance which meets the rigid requirements demanded of it.

FIRE EXTINGUISHERS
May Display "Emergency" Approval Label

ANY CONFUSION which may arise concerning the distinction between fire extinguishers bearing standard Underwriters' Laboratories approval and those bearing the Laboratories "EAS" approval will be ended by the following explanation.

Standard approved extinguishers bear the usual Underwriters' Laboratories label, which reads "Underwriters' Laboratories Inspected," and gives the serial number of the label and pertinent information on the classification of the extinguisher. That label signifies that the unit conforms to the Laboratories' "pre-war" specifications covering types of materials, details of construction, performance requirements, and so on. Such extinguishers are now available only to very high priority holders.

When war started, restrictions on the use of critical materials made it necessary for the manufacturers of standard extinguishers to develop new models

Ultra high-speed motor—a veritable "whirling dervish"—being speed-checked with a stroboscope

using non-critical materials. The solution to this problem was undertaken in co-operation with Underwriters' Laboratories, and a realistic decision was made to sacrifice durability in favor of performance.

Emergency Alternate Specifications were then developed which permit the use of substitute materials, and extinguishers produced under these specifications bear an "EAS" approval label—that is, the Underwriters' Laboratories inspection label has the letters "EAS" added and also the year of manufacture.

Translated into practical terms, this label signifies that the unit on which it appears will perform as well as the standard model, but will require more careful maintenance and cannot be expected to resist corrosion or to stand up as long as the standard type. When standard equipment is once more obtainable, the "EAS" approval will be withdrawn. "EAS" extinguishers now available include pump, tank, and foam types. Many of these are going to priority holders, but some are being released to the general public.

Both labels are intended as indications to insurance inspectors of the degree of protection the equipment affords an occupancy. They serve as comparable indications of reliability to the owner or prospective purchaser of fire-fighting equipment.

"WHIRLING DERVISH"

Grinder Motor Turns at 60,000 Revolutions Per Minute

THE WORLD'S fastest industrial motor—an electrical "whirling dervish" revolving 1000 times a second—has been built by Robert M. Baker, of the Westinghouse Research Laboratories, to drive high-speed grinders that put a mirror-like finish on hard-to-reach internal surfaces of plane and tank engines.

Such grinders are now powered by larger, slower motors connected to the grinding wheel shaft by belts and pulleys. These belts tug at the grinder, sometimes pulling it out of alinement, and they often break because they have to be thin and pliable to bend around the small pulley on the grinder shaft. The new high-speed motor can drive such grinders directly, eliminating production delays for belt replacement and increasing grinding accuracy.

At top speed the rotor of the new motor travels more than 300 miles an hour at its outside edge, less than an inch away from the center of the motor shaft.

"To meet the millionths-of-an-inch tolerance required in finishing aircraft engine parts," Mr. Baker explains "the grinding wheel must cut effortlessly and smoothly, something that can't be accomplished at low speeds.

"Many of these grinding wheels are less than an eighth of an inch in diameter, no bigger than those used by dentists, but they must attain high speeds at their grinding edges. Experience has shown that the best grinding speed is about a mile a minute on the face of the wheel.

"In the future," Mr. Baker continues, "grinders may have to go to ever higher speeds as tolerances grow smaller and smaller. So we are designing another motor that will turn 120,000 times a minute, twice as fast as the one already built."

Although it is only the size of a 1/16-horsepower motor operating on ordinary electric current, the new grinder motor develops 80 times that much power at its top speed. Water flowing through a jacket that surrounds the motor and its bearings keeps the compact power unit cool. The bearings are lubricated by a pump that forces oil through the space between shaft and bearings, a gap less than one two-thousandth of an inch wide.

SEARCHLIGHT

Uses 900-Watt Air-Cooled Mercury Arc

PROVIDING more than 7,500,000 candlepower, a new type of 12-inch high-intensity searchlight makes use of a tiny match-shaped mercury lamp cooled by compressed air. With its 900-watt mercury lamp, this searchlight is four times as powerful as the conventional incandescent searchlight of the same size.

Such heat is created by the mercury arc inside the lamp that cooling air must constantly be forced through a rubber hose into the top of the searchlight drum by an air compressor. Warm air escapes through small ventholes in the bottom. With air cooling, the searchlight can be operated in all types of weather.

New arc searchlight, with back removed

The light beam, pale bluish-green in color, is flat and narrow, making it suitable for many specialized applications such as lighting of distant horizontal surfaces from a low mounting height. Three circular louvers prevent the escape of stray light.

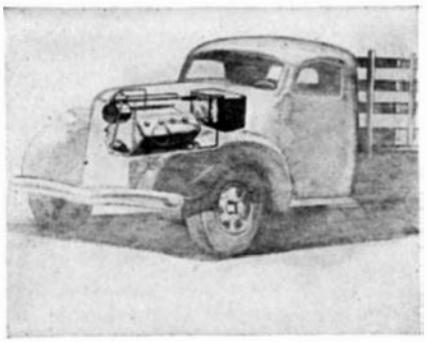
The searchlight is equipped with various safety features which insure among other things sufficient cooling air before the lamp is turned on, and extinguishment of the lamp if the rear door is opened while the current is on.

A 24-inch air-cooled mercury searchlight, using the same tiny lamp and built on the same principles, provides over four times the amount of candlepower supplied by this 12-inch mercury model.

MOTOR WARM-UP

Expedited by Improved Oil-Diluent System

OUT OF the wartime necessity that planes be able to take off within seconds in sub-zero temperatures comes a solution to the problem of starting an automobile or a truck or a tractor on bitter-cold mornings. The answer is in the form of a new cold-weather lubrication system for aircraft engines that is adaptable to all types of internal combustion engines.



Oil-diluent system on a truck

The system, devised by Leslie T. Miller, Glenn L. Martin Company engineer, consists of a series of basic improvements on the method of diluting lubricating oil with gasoline in order to produce quick starting of aircraft motors in cold weather.

Each engine of an airplane motor has its own reservoir of lubricating oil, holding as much as a hundred gallons. When the motor is running, oil leaves a warm-up compartment within the reservoir, passes along a pipe line into the motor, leaves the motor to pass through an air-cooler, and from there returns to the warm-up compartment.

Under the unimproved method a pilot, after landing in cold weather, presses a button which introduces gasoline into the oil before it enters the motor, and assumes that when he wants to take off some hours later the warm-up compartment, the motor, and all oil

lines will contain a thinned supply of lubricant. What sometimes happens, however, is this:

The diluent, being introduced *before* the oil enters the motor, is partially evaporated out by the hot motor. The result is that completely thinned oil is left only in that part of the line between the point where the diluent is introduced and the motor itself.

When he goes to take off some hours later the pilot may find, while he has perhaps enough thinned oil to start with, the rest of the system is jammed with slugs of thick oil which are likely to burst the air-cooler. An added tragedy is that the plane is usually off the ground by the time the air-cooler bursts, with the result that the oil supply fails, the motors burn out, and the plane crashes.

Even if the damage does not go that far, the old method has the disadvantage of allowing the used oil to return only to the warm-up compartment, with the result that the same oil gets used over and over again, being only gradually replenished by new oil from the reservoir.

The new method, which has proved itself on war fronts where planes must take off within seconds after standing for hours in bitter cold, disposes of these dangers.

In the first place, it introduces the diluent into the oil *after* the oil has passed through the motor. This prevents the hot motor from distilling out the highly volatile diluent, and thus leaves the lines, motor, and warm-up chamber full of thinned oil.

Second, the new method sets up a by-pass which keeps cold and thick oil from getting into the air-cooler and bursting it.

In the third place, the new method permits the use of dual return lines to the oil reservoir—one leading into the warm-up chamber and the other into the reservoir as a whole.

A thermostat located at the point where the diluent enters the oil decides whether the oil shall by-pass the cooler and whether it shall return to the warm-up compartment or to the reservoir as a whole.

Having solved one of the most acute problems of cold-weather flying, Martin engineers believe the automotive industry will adopt, when it gets into production again, this method of starting trucks and tractors and automobiles on bitter-cold mornings.

SUBSTITUTIONS

Make Engineers Resort to Common Substances

MINERAL OIL from the drugstore shelf, common starch from the household laundry, a pigment developed for the paint industry, and many other substances, have been commandeered by RCA chemical engineers to help produce the dependable radio, sound, and electronic equipment for our armed forces.

This war brought to RCA, as to other industries through the country, new and more rigid specifications for completed products, more critical inspection standards, and, almost simultaneously, materials shortages necessitating the use of new and often relatively unknown materials. Resulting problems have been numerous, but the answers have been found in applied science.

Mineral oil was pressed into service by the RCA Chemical Engineering Section when it was found that the wax ordinarily used to impregnate radio coils would flow when too hot and crack or crystallize when too cold, all within the extremes of temperature at which these coils would be required to function. Either failure would expose the wires to moisture, adversely affecting the electrical properties of the coils. This problem was solved by the development of a new impregnating agent, made from mineral oil and cumar resin, which will withstand both extremes of temperature without loss of its protective characteristics.

But a tougher problem was posed by the need for a means of soldering aluminum to permit the use of this lightweight metal in products where weight is an important factor, such as chassis for aircraft radio equipment.

Since aluminum cannot be directly soldered in a commercially convenient manner by any known method, a means was sought for plating the aluminum with another metal, to provide an easily solderable surface and, at the same time, a better means of assuring good electrical contact. But neither can aluminum be directly plated, so an indirect approach was necessary.

After some study the chemical engineers found a conducting material which could be applied to aluminum as a film by means other than plating, and developed a process for applying it and for subsequent plating of the aluminum thus treated.

Common starch came to the rescue as a fluxing agent for various soldering operations when it was found that neither rosin nor zinc chloride, which are the agents most extensively used, would do the job in certain applications.

Borrowings from the paint industry involve the use of a black oxide of

iron, specifically developed as a pigment, as the essential material in the manufacture of cores used in controlling the effective permeability of magnetic circuits.

Such satisfactory solutions of materials and process problems as enumerated have been possible because of an extensive background of experience in the various kinds and applications of engineering and science.

SUGAR BEET SEED
Improved Through Use of a Grindstone

BECAUSE science "put its nose to the grindstone," sugar beet growers of the United States saved more than three million man-hours of labor in 1943 and even more significant gains lie ahead.

The saving in labor was made possible by applying mechanical pressure to sugar beet seed, thereby solving a problem which has vexed the industry for generations. The problem arose from the fact that the seed of the sugar beet is not a single cell, but rather a group of cells held together in a cluster. Seed clusters, of course, are not uncommon in nature. Beans and corn are familiar examples, and in most cases it is not difficult to separate the individual seeds from the group. Sugar beet seed, however, presents a special problem. The seed cluster is a hard, tight ball, difficult to handle because it is smaller than a pea in size.

When beet seed clusters are planted they may send up a number of sprouts, and since the beet needs "elbow room" to grow and mature, it is necessary to thin the stand so that only single plants remain. Thinning has always required hand work, and there seemed no method of eliminating it unless the seed itself could be changed.

For a number of years plant breeders attempted to develop a strain of beets which would produce single-cell seeds. Some such seeds were grown, but it was never found possible to transmit the characteristics of singleness to succeeding generations, and the experiments were finally abandoned.

Then Professor Roy Bainer of the Department of Agricultural Engineering of the University of California rigged up a device in which a grindstone thrusts the seed against a shearing bar, and under the pressure thus created the cluster splits into single-unit seeds. These single seeds can be planted at regular intervals in the row, and the thinning can be done with a long handled hoe, or with a variety of mechanical tools which require no hand labor whatever. One of these tools is an adaptation of the recently developed cotton chopper, which consists essentially of revolving knives.

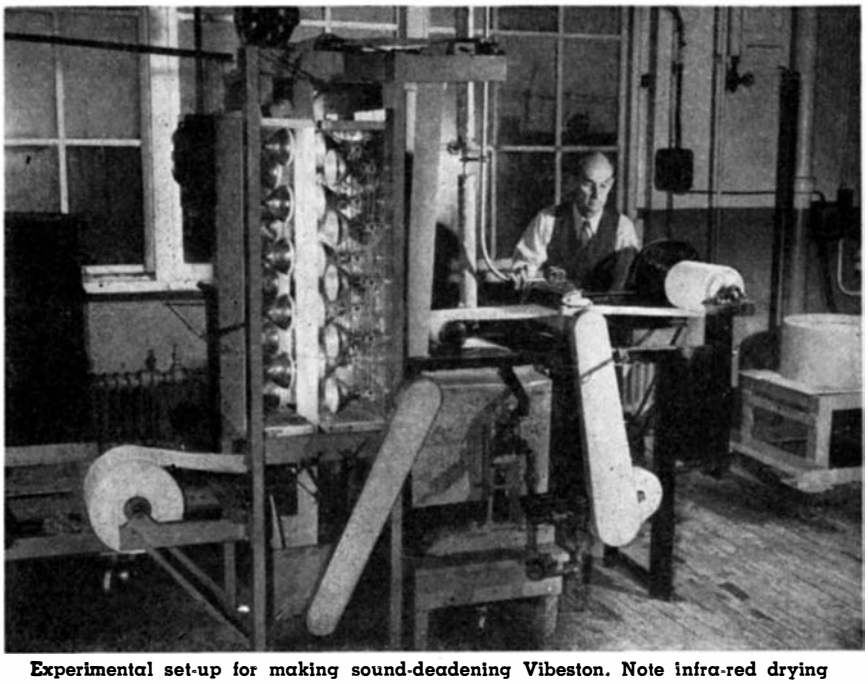
The new seed—called sheared or segmented seed—was used extensively for the first time in 1943. It is estimated that the sheared seed reduces the hand labor requirements by at least ten hours an acre, and still greater savings are probable when planting techniques are perfected.

SOUND-DEADENING
Afforded by New Asbestos Composition

A SOUND-DEADENING material which will go far to alleviate a condition that threatens thousands of members of American airplane crews with the possibility of either total or partial deafness is made of asbestos and other nonstrategic materials and is known as Vibeston. It serves both to deaden sound and dampen vibration. The only other known material comparable for this purpose in planes is mica, the major supply of which, from India, was cut off by the war.

Vibeston however, is as much as 50 percent lighter than mica; hence larger areas of planes can be insulated. Moreover, many planes which heretofore had to sacrifice all noise dampeners and vibration deadeners in the interest of lightness can protect the hearing of their crews through the use of the new material.

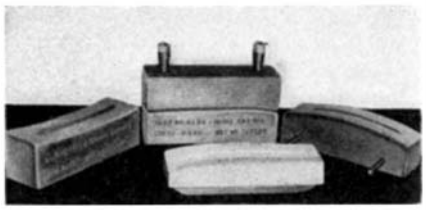
Mass production of Vibeston is now in progress. Its use will be confined to war purposes for the duration. Its construction is such that after the war it may be used in air-conditioning units and other forms of manufacture where vibration and noise are prime factors.



Experimental set-up for making sound-deadening Vibeston. Note infra-red drying

PROTOTYPE DIES
Made Quickly With Low Melting Point Alloy

A NEW production system for making drop-hammer dies for prototype and sample parts embraces the following steps: Construction of a master model or template; production of a plaster pattern of this master model by casting;



Low melting point alloy used in dies. Left: Solid Cerrobend male punch. Right: Female die of same metal. Center foreground: Original plaster model. Center background: A complete die set (punch and die) with drop-hammer mounting

casting dies, embodying the identical contours of the master model, from the plaster pattern.

This process not only produces a die for stamping the parts, but also provides a means of casting checking fixtures for other subsequent operations on the part.

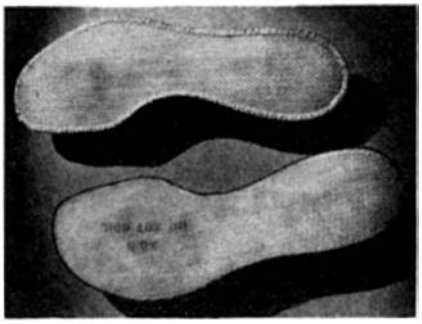
The dies are cast directly from standard size plaster patterns of the part, in a large tank containing circulating cooling liquid. The cooling of a die is accomplished in approximately 45 minutes. The metal used—a standard, low melting point alloy known as Cerrobend—can be pumped through a long, rubber hose to any job that is ready for pouring. As Cerrobend cools it doesn't shrink, which eliminates all problems of machining. Anchor lugs and cores for holding the die in the drop hammer are mounted and cast in place during the pouring.

Aluminum, steel, and plastic parts can be made with such dies in quantities of from one to fifty or more, depending on the type of material, thickness, and accuracy required. The system is now in use in plants of the Castaloy Corporation.

INNERSOLES
Made of Plastic, Are Washable, Sanitary

AMONG UNUSUAL wartime uses of modern plastic materials is the Saran screen innersole developed recently by the Quartermaster Corps for use in jungle boots and other military footwear.

The soles, made up of several layers of Saran screen stitched or welded together at the edges, are resilient, flex-



Sanitary innersoles

ible, and tend to ventilate the bottom of the foot. This latter characteristic is expected to aid in the control of fungus foot infections, such as athlete's foot, which are prevalent in humid climates.

Since the Saran plastic absorbs no moisture, the soles may be washed quickly with soap and water, gasoline, or other common cleaning agents and so can readily be kept in a sanitary condition.

The Saran screen used is the same material employed for insect screening in hot, moist climates because the plastic screening is not subject to rusting or corrosion.

CINCHONA TREES

Discovered in Large Quantities in South America

GREAT NUMBERS of wild cinchona trees, needed for quinine and totaquine for war purposes, have been discovered in regions of the other Americas where previously they had not been known to exist in commercial quantities. Specialists from these countries and from the United States Office of Economic Warfare are busy solving transportation and labor problems in these regions, to assure an added supply of the highly strategic cinchona bark, needed for the production of quinine and totaquine to fight malaria. Before the war, the world's main cinchona source was the Netherlands East Indies, to which the trees had been transplanted from South America. Recently returned from a cinchona survey in Guatemala, Colombia, Ecuador, Peru, and Bolivia, Keith Cone, Chief of the Cinchona Section of the Office of Economic Warfare, reported that "there are apparently larger quantities of cinchona than was thought in these countries."

IRON TANNING

Offers Promise to the Leather Industry

OUR SUPPLY of vegetable tanning materials, as well as the chromium used to tan most of the garment and shoe upper leathers for both civilian and military purposes, depends largely upon ships and safe ocean transportation. The importance of developing domestic materials to meet any emergency is illustrated by the fact that only a short time ago the danger of a serious shortage of chromium was such that it was declared a critical material by the War Production Board. Since iron had been shown by previous investigators to offer some promise as a successful tanning agent, and since an abundant domestic supply of this metal exists, an investigation of the use of iron salts for tanning, with special attention to the replacement of chromium salts, was undertaken by Joseph R. Kanagy and Ruth A. Kronstadt at the National Bureau of Standards. At the present time the situation with respect to chromium for tanning has been greatly relieved by the utilization of low-grade domestic ores in the manufacture of chromium salts. Nevertheless, the results of the Bureau's work are of interest.

These results, which are reported in the Journal of Research, indicate that ferric sulfate may be satisfactorily used if certain organic acids are added to the tanning solutions to stabilize them. Lactic, citric, gluconic, and hydroxyacetic acids were found suitable for stabilizing the iron tanning solutions at the pH required for successful tanning. Without them the iron precipitates as the hydroxide, a form useless for this purpose.

Considerably more iron (Fe_2O_3) than chrome (Cr_2O_3) is required to tan a piece of leather. All hides tanned with the iron contained at least 10 percent of (Fe_2O_3), whereas good leather can be prepared from chromium salts which contain only 5 percent of Cr_2O_3. Experiments with hide powder showed that as much as 25 percent of Fe_2O_3 combined under optimum conditions.

Iron tanning solutions appear to have properties similar to those of chrome tanning solutions. Results of accelerated aging tests on iron-tanned goat and calfskins indicated that, on the average, the iron-tanned leather is slightly less resistant to aging than the chrome-tanned leather.

WOOD CARVING

Speeded by Use of Compressed-Air Tools

GUIDED by the skillful hands of the wood carving expert, the modern compressed-air tool is putting pattern making on a new schedule in today's wartime production. According to the Compressed Air Institute, many new and remarkable achievements are being

Carving with a compressed-air tool

recorded through the application of air tools to wood pattern making. Many of these production results are contributing directly to our war effort and point to even greater usefulness for compressed air in fields not yet explored.

For saving time, lowering costs, and in many respects improving the quality of the woodworker's art many types of wood cutting tools are available. These light and compact hand-held, air-operated tools are in operation in many foundries and pattern shops doing both light and heavy jobs of routing, carving, and chiseling.

Craftsmanship in wood, like that in stone, may become better known, more plentiful, and less expensive because air tools in no way disturb the skill of the worker, while at the same time increasing his output many times.

DIESEL RING STICKING

Recorded to Indicate

Overhauling Needs

DEVELOPMENT of an instrument which measures and records the blow-by of gases in Diesel engines, thereby indicating whether and when rings are sticking, was announced at the National Fuels and Lubricants Meeting of the Society of Automotive Engineers.

The device, which was said to have accurately recorded sticking rings on every test run so far made and promises to be invaluable in saving time and labor by indicating overhauling needs, was described by R. R. Proctor, A. J. Stock, and D. J. Wangelin, of The Pure Oil Company's Mechanical Laboratory.

The instrument was said continuously and mechanically to record blow-by in cubic feet per minute, revealing the point at which ring-sticking starts and indicating even those temporary periods during which ring gaps are in line or ring flutter occurs.

In testing, the Diesel's crankcase is sealed and all gases are passed through a surge chamber and thence through a standard household gas meter to which a recording unit is attached. Use of a standard gas meter, of a recording unit rebuilt in simple fashion, and even of old recording charts, was said to contribute to economy.

RAYON INSULATION

Being Used on Interior

Telephone Wires

ACETATE rayon yarn is replacing silk for insulating interior telephone system wires and, according to telephone technicians, has proved superior to silk for this purpose, states the American Viscose Corporation. The properties required for telephone central-office wire insulation are stability of electrical characteristics under varying atmospheric conditions, and good aging properties. Experience has shown that acetate rayon surpasses silk in its electrical properties and possesses entirely satisfactory aging properties. The rayon covering is used today in the insulating covering of switchboard wires, switchboard cable wires, and distributing-frame wires.

Metals in Industry

(*Continued from page* 117)

In the new practice the part is heated as usual to above its critical temperature but instead of being quenched in oil at room temperature it is quenched in a liquid bath (a molten salt or lead) at some temperature between 400 and 800 degrees, Fahrenheit, and held in the bath for a given period of time. The steel thus transforms to a new structure known as "bainite" which has properties similar to those of the conventionally treated steel, but which has involved in its production no drastic quench and hence no part distortion.

No subsequent machining to correct distortion is thus required. Furthermore, if the material is heated in a molten salt and then hot-quenched into another molten salt bath, both of which are inert to the steel, it will be neither scaled nor decarburized by the treatment. The part can thus be completely machined in the soft condition prior to hardening, hardened by the hot-quench-in-salt method, and cleaned of adhering salt, and is then ready for inspection and shipping. This new method has been demonstrated by the Roth Manufacturing Company, as applied to the hardening of booster holders and other precision ordnance parts in Ajax-Hultgren electric salt bath furnaces.

BRIGHT GAS QUENCHING

Makes Possible Aircraft Use

Of Welded Steel Tubing

WHEN the aircraft building program was drastically increased at our entrance into the war, *welded* alloy steel tubing began to be widely used for fuselage structures, wing beams, engine mounts, and so on. The aircraft industry had formerly insisted on *seamless* tubing, but the heavy demands could not be filled by this type alone, hence the welded tubes were given their chance and have succeeded with a vengeance.

Welded tubing, however, must be made of steel containing a *minimum* of carbon and alloy content, since such ingredients add to the difficulties of welding. On the other hand, the high strength of the tubing is ordinarily obtained by heat treatment, and for this purpose a *maximum* of carbon and alloy content is desirable. Where then, can a tubing material be found that is easily weldable on one hand and highly hardenable on the other?

This dilemma was broken by using the traditional weldable chromium-molybdenum or chromium-molybdenum-nickel tubing steel and applying a special heat treatment that permitted the use of the minimum carbon and alloy content. This heat treatment is more drastic than the conventional "normalizing" (fast cooling in air) and has been called "gas quenching." It consists in passing the heated tubes through a zone filled with a non-oxidizing gas atmosphere that is being blown-in and drawn-out of the zone (that is, recirculated) at a rate more than ten

times that of the "fast" cooling zone ordinarily used for normalizing seamless tubing.

Faster cooling is obtained by "gas quenching" because the protective gas keeps the steel bright and thus increases the rate at which heat can be removed from it, the specific heat of the protective gas makes it an inherently faster cooling medium than air, and the cooling medium is removed at a tremendously higher rate.

The use of bright gas quenching has made it possible to meet Army-Navy specifications for welded aircraft tubing on a large production scale, according to a paper prepared for the American Society for Metals. The tubes can be welded to finished size and no cold drawing is necessary. The new process, developed by William Lehrer, of Surface Combustion Corporation, is typical of the wartime materials-saving, higher-production improvements in heat treating that are here to stay.

Measuring Roughness

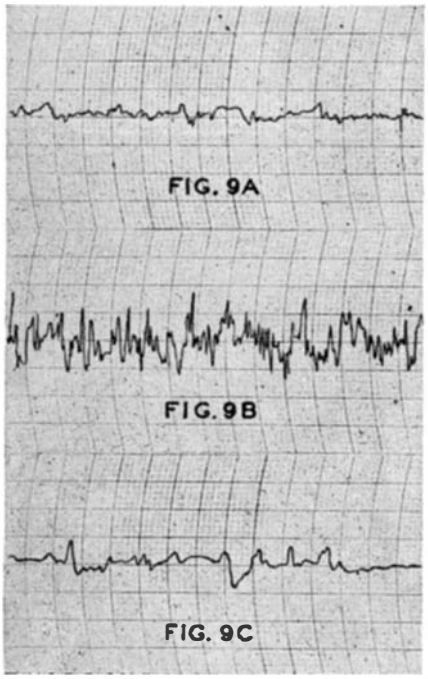
(*Continued from page* 119)

surface so that the area of contact is greater per square inch (the same heat conductivity) decreases the material cost but increases the machining cost. The optimum, of course, lies in between.

In airplane engine design the decrease in weight is of such paramount importance that all of the effort is usually placed on the smallest size and weight of parts. It is a practice in this industry to run engines for 7 to 10 hours under full power output rating and then completely disassemble them. The parts are then carefully examined to see whether any of the bearings were overloaded or were scored due to surface particles breaking loose.

The quick-reading stylus method for measuring finish is also widely used to check each part as it comes off the production line. This is necessary since grinding wheels may go out of round or chatter, the operator may be taking too heavy a cut, and so on. Figure 8 shows a typical production set-up for measuring wrist pins. Each pin is set in the V block and the drive arm slides the diamond stylus and supporting shoe over a small section of the surface. A magnified image is drawn on the graph paper. For a graph of the actual pin under test see Figure 9A. It should be noted that the horizontal and the vertical magnifications are not equal. To make them equal would make the chart clumsy to read. Actually the surfaces are stretched in the vertical direction. Stretching them to their correct proportions would make the true shape appear smooth and gently undulating.

The three traces in Figure 9 have a magnification of 80 on the horizontal axis and a magnification of 4000 in the vertical direction. Therefore, to get a true similarity between the drawn curve and the surface, the horizontal axis must be stretched to 50 times its present length. It can thus be realized that the surfaces measured are relatively smooth. To draw the curves correctly this way would use a great deal of paper. It is for practical reasons then that the horizontal magnification is kept low.



Traces of three different surfaces, made by the Brush Surface Analyzer. Figure 9A is from a fine-ground wrist pin surface, Figure 9B is from an average ground finish, and 9C is from the barrel of a plastic fountain pen. None of these surfaces has these actual contours, all contours being "stretched" 50 times more vertically than horizontally. Each of the finer lines of the cross-section paper represents 1/100,000 inch (ten micro-inches) vertically

Curve 9A is a typical curve for a fine-ground surface such as the one on a wrist pin, shown in Figure 8. The sensitivity of the chart is so set that deviations in the surface of 10 micro-inches will deflect the chart pen one millimeter. It can be seen that this surface has maximum deviations of the order of 30 micro-inches. The average deviations are of the order of 8 micro-inches, or 8/1,000,000 inch.

Curve 9B has the same magnification of the co-ordinates. It is the trace of a ground surface which is obtained from the average grinding wheel—usually specified as "ground finish." The maximum deviations here are of the order of 80 micro-inches with the average running about 25 micro-inches.

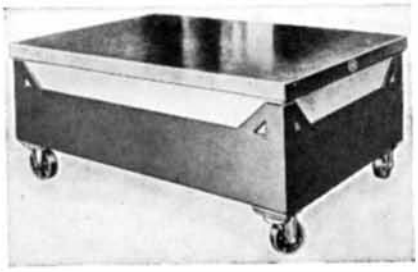
Curve 9C is the trace of a well finished barrel of a plastic fountain pen. The non-uniformity of the trace is due to handling of the barrel. The material, being soft, is deformed easily under load.

This brief sketch, surveying the uses of surface measurement, shows that the art is in its early stages of development and that much remains to be investigated. The generation of a good surface is enticing because a delicate touch in the finishing operation may make a tenfold increase in the performance of that surface.

New Products

SURFACE PLATE

DEMONSTRATING that granite is entirely feasible for making even the largest size surface plates, the Herman Stone Company recently turned out a 5000-pound giant which measures four by six feet. Despite its great size and weight, a special steel angle iron wheel



Non-magnetic, glass-like

carriage facilitates ease of handling and makes the plate readily available for service in any part of the plant. Like its smaller counterparts, it presents a smooth, non-magnetic, glass-like surface. This plate may be finished to an accuracy of 3/10,000 inch, while the standard smaller sizes are held to an accuracy of 1/10,000 inch. Being harder than the hardest tools, as well as rust-proof and warp-proof, this huge granite surface plate is practically indestructible.

TEST PLUGS

DEVELOPED for use with the Rotobridge (see page 12, January 1944, Scientific American) in testing electronic equipment, CML production plugs are now available generally for use by electrical manufacturers. These plugs are 5 inches long and 1¼ inches in diameter, made with a heavy steel barrel and fitted with a wooden handle to permit ready removal from socket. All pins are case-hardened steel to assure long life, yet may be replaced when worn or broken. In addition to Octal and Loktal types, these plugs are available in 4, 5, 6, and 7 pin models, small and medium.

DRILL-PRESS FEED

A SIMPLE power feed for drill presses, manufactured by the General Pacific Corporation, and known as the Hydra-Drill, provides a controlled, automatic, fully adjustable power feed for most makes and models of drill presses.

Powered by air, this tool is designed to operate automatically a drill press so that the customary hand feed, while it can be used if necessary for individual operations, is unnecessary for fast production work. The Hydra-Drill permits the operator to devote full time and attention to feeding the work to the drill press. Adjustable stops permit accurate adjustment for all drill-press operations such as drilling, counterboring, spot facing, blind drilling, reaming, and other operations on any type of materials or parts. The range of feed is infinite and can be instantly regulated for fast drilling of soft materials or slow drilling of hard materials.

One particularly valuable feature of the pneumatic feed lies in the fact that the rate of feed of the drill-press spindle can be adjusted so that the pressure of the drill on the work is exactly right for any particular drilling operation, regardless of the size of the drill which is used and the rate of speed at which the drill is operated.

PLATE PUNCH

WITH THE new Wales plate set system for punching holes in flat material, holes may be punched in any pattern in sheets up to 43 inches by 45 inches. The minimum center-to-center hole location is one half inch in any direction.

Each plate set consists of two plates which are made of Walesite, a plastic material uniquely applicable to this new method of hole punching. These are separated by spacer bars, also of Walesite, and are held together rigidly by bolts and dowel pins.

With a master templet, holes are located on top plate of the set. Then larger holes are drilled in top and bottom plates of the set for punch assemblies and dies. Corresponding pattern holes in both plates are drilled in the same operation to assure perfect alinement of punch and die. The entire punch assembly, consisting of punch, stripping spring, guide, and lifter spring, is in-

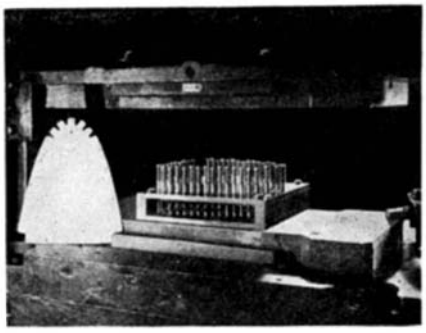
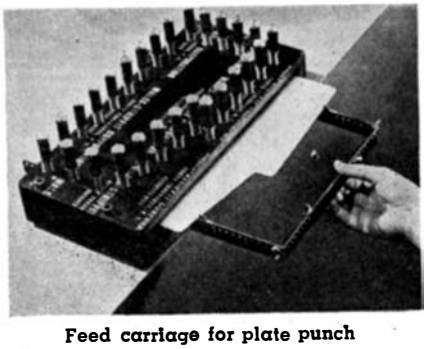


Plate-punch assembly in press



Feed carriage for plate punch

serted in top plate and the die is press fit into the bottom plate.

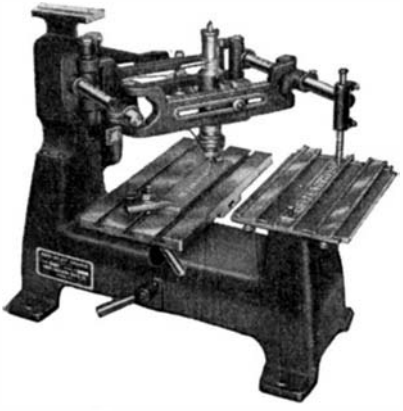
The outstanding advantage of this system is the quick, easy manner in which an entire plate set assembly can be made outside the press. This assembly is ready to operate at the first down stroke of the press ram.

Adjustable feed carriages used with the plate set carry, nest, and remove blanks rapidly and with a high safety factor. Feeding and removing blank with the carriage requires only a flip of the hand.

PANTOGRAPHIC ENGRAVER

ADDING to its line of Panto engraving, marking, and etching machines, H. P. Preis Engraving Machine Company now offers a unit for heavier and more varied engraving work than that performed by its standard Model UE machines. This equipment is said to be suitable for engraving on all metals and plastics, for electrical marking on steel and other ferrous metals, and for acid etching on metals or glass.

Designated as the UE-3 Panto Engraver, the machine can be equipped with a forming guide attachment to engrave on concave, convex, spherical, and beveled surfaces. A depth-of-cut regulator is available, to engrave on un-



Versatile engraver

even or curved surfaces. The machine is equipped with endless-belt drive and has four spindle speeds, ranging from 5000 to 12,000 revolutions per minute, making it adaptable for all types of engraving.

This machine is easily converted from electrical marking to acid etching by replacing the spindle bracket with standard marking or etching units.

PORTABLE GENERATOR

REPORTED to be the most powerful generator of its size ever built, the new air-cooled Epcon B-30 unit, designed to meet wartime needs for portable power and light, delivers 3000 watts at 110-volts A.C., 60 cycle. Net weight is only 305 pounds. Length, including the base, is 34 inches; height 26 inches.

The field ring is annealed cast steel which produces top electrical efficiency for given weight and at the same time gives maximum support and stability to the generator. Cast iron fittings secure both the generator and the Briggs and Stratton engine to oak sled runners which serve as a strong but light base.

End bells, instead of being solid and heavy, are of open design like a wheel with spokes. Dust covers are of light weight steel spinnings. The V-belt

Most powerful of its size

drive makes a saving in weight over direct-drive models on which the generator must be heavy and solid enough to be held exactly in the right position for the direct driveshaft.

VOLTAGE SELECTOR

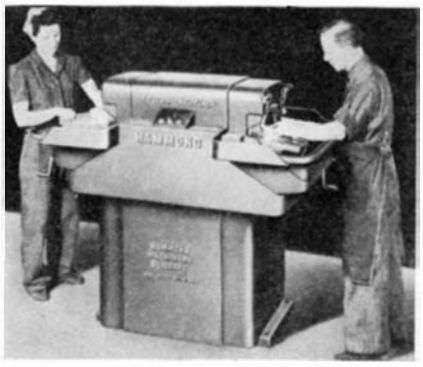
A NEW magnetic voltage selector manufactured by Zenith Electric Company, while especially developed for an electro-plating process for anodizing aluminum on A.C., has many other uses where like applications of current are required.

The Zenith selector is for transferring in steps from 2 to 40 volts. The arrangement is such that, when transferring, the main contact opens before the secondary contact opens, and closes after the secondary contact is closed. Arcing is thus effectually eliminated.

The new unit embodies automatic main magnetic contacts, and automatic main switch contacts for nine positions at 2½-volt intervals.

CARBIDE TOOL GRINDERS

COOLANT control is a feature of a newly designed line of 10- and 14-inch carbide tool grinders. The coolant spouts are fully adjustable, with wide outlets which permit the correct flushing of the work by a slow cascade of coolant, supplied without force. Large splash pans around the table provide adequate protection to the operator, do



Embodying coolant control

not obstruct vision of the work, enhance operating freedom in movement of tools on the table, and prevent coolant splashing over onto the floor. It is said that this new arrangement provides complete control of the coolant while grinding wet; thus operator and floor are kept completely dry.

These machines, just announced by Hammond Machinery Builders, are especially designed for wet or dry grinding of carbide tools.

GOGGLE-CLEANING CABINET

DEVELOPED by Mine Safety Appliances Company to encourage workmen to wear their goggles and keep them clean, a new goggle-cleaning cabinet is equipped with Fogpruf—an efficient lens cleaning and anti-fogging agent—and optical wiping tissues. The unit is designed for mounting in strategic work locations and in repair rooms, tool rooms, locker rooms, or on traveling goggle dispensing carts. Two vials of Fogpruf are concealed within the dispensing block, permitting the cleaning of two pairs of goggles at one time. A tap on either button of the dispenser sprays Fogpruf on the lens. Cleaning tissues are withdrawn from an opening in the top of the dispensing station.

TACHOMETER

A SELF-ENERGIZED Ideal tachometer, recently announced, consists of a small generator coupled electrically to an electric meter. The generator and meter are made as separate elements and coupled together by a bayonet lock. The units may be used together as a "hand type" tachometer or, for many applications including permanent mounting, the generator and meter may be separated and connected only by a two conductor electric cord. A five-foot cord complete with coupling plug is provided, but a cord up to several hundred feet long (of proper size wire) can be used without introducing an appreciable error in scale reading.

The Ideal tachometer is available in two sizes for 0 to 2500 and 0 to 5000 revolutions per minute.

Self-energized tachometer

MASKING STICKERS

MASKING stickers, cut to the size and shape specified by manufacturers, have been developed by Avery Adhesives from a material which is easy to handle and which may be applied without moistening and peeled off without scraping or tearing. These pre-cut masking stickers eliminate the necessity of masks being cut by the operator by hand and experience has shown that they greatly increase speed of masking operations, particularly in covering smaller areas.

LUMINAIRE

DESIGNED for easy continuous strip installation, a new light-weight fluorescent luminaire with one-piece, double-length hood and two full-size reflectors is announced by Westinghouse Electric and Manufacturing Company.

Available for use with four or six 40-watt or four 100-watt lamps, the new

Equivalent of two conventional units

luminaire is the equivalent of two conventional units. The hood is fabricated from sheet steel with all ballasts, lamp holders, and starter sockets mounted and wired as part of the channel assembly. Sliding hangers permit suspension from any part of the hood. Mounting arrangements are available for any application. The moisture-resistant, non-metallic reflectors are covered with a multi-coat polymerized finish which provides a reflection factor of 85 percent or more.

AC-DC ELECTRODE

A NEW general-purpose arc welding electrode for welding mild steel in all positions, with either alternating or direct current, named "Fleetweld 37," is the most recent addition to the line of Lincoln electrodes for welding mild and low alloy steels.

"Fleetweld 37" was originally designed as an easy striking, smooth operating electrode primarily for light-gage material. Extensive use in production has also shown it to be a very fast operating electrode under all conditions.

The ability of "Fleetweld 37" to withstand higher currents, both alternating and direct, makes possible higher welding speeds than normal; its easy handling characteristics in all positions make it an ideal electrode for general-purpose work. The fact that with proper currents it will neither stick to the work nor burn through makes the electrode especially desirable for light-gage welding.

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.)

POST-WAR JOBS, by Alfred P. Sloan, Jr., surveys the challenge that confronts American enterprise today and expresses an opinion as to the methods by which the objective should be approached. *General Motors Corporation, 1775 Broadway, New York, New York.—Gratis.*

THE CORRONIZING PROCESS OF METAL COATING is an eight-page illustrated pamphlet describing the process in some detail, putting forth its varied applications, and listing its advantages. Essentially, Corronizing consists of applying layers of metals and alloys having unusual corrosion-resisting properties. *Standard Steel Spring Company, Corronizing Divison, Coraopolis, Pennsylvania.—Gratis.*

CARE AND REPAIR OF THE HOUSE contains 121 pages of scientifically checked facts on how to keep the house and its equipment in proper condition. *Superintendent of Documents, Government Printing Office, Washington 25, D. C.—15 cents in coin.*

HOW ELECTRONIC TUBES WORK is a 24-page non-technical booklet illustrated with 117 sketches and photographs. Designed primarily for industrial engineers, the eight basic types of industrial electronic tubes and their uses are described. Request booklet GEA-4116. *Dept. 6-215, Publicity Divisions, General Electric Company, Schenectady 5, New York.—Gratis.*

STAR CATALOG, NO. 43-S, contains a large amount of technical data on metal-sawing operations—both hand and power. *Clemson Brothers, Inc., Middletown, New York.—Gratis.*

"ALLO MAROC," by C. L. Stong, is a 16-page illustrated booklet which dramatically presents the production battle being waged by the communications industry. *Western Electric Company, 195 Broadway, New York 7, New York.—Gratis.*

MACWHYTE WIRE ROPE is a 160-page guide for wire rope buyers, 60 pages of which are devoted to helpful information on the conservation and care of wire rope. *Macwhyte Company, Kenosha, Wisconsin.—Gratis. Request catalog G-15 on your business letterhead.*

OIL INDUSTRY AND TRANSPORTATION. . . PRE-WAR AND POST-WAR, by P. Harvey Middleton, is a 60-page study outlining the development of the petroleum industry and the services rendered to that industry by various forms of transportation. It endeavors to estimate the post-war demand for petroleum. *Railway Business Association, 38 South Dearborn Street, Chicago 3, Illinois.—50 cents.*

FOUR NEW BUSINESS STUDIES, running from four to twenty-eight pages cover: What Management Can Really Do to Reduce Absenteeism; Representative Cost Systems in the Plastics Industry; Preventing and Correcting Low Power Factor; and Scientific Selection of Office Personnel Increases Production. *George S. May Business Foundation, 111 South Dearborn Street, Chicago 3, Illinois.—Gratis. Request these bulletins on your business letterhead.*

REFRIGERATION AND AIR CONDITIONING . . . IN WAR. . . IN PEACE is a lavishly illustrated pamphlet describing the art of manipulating and controlling temperature and humidity in many phases of industry, on the home front, and on the fighting front. *Air Conditioning and Refrigerating Machinery Association, Southern Building, Washington 5, D. C.—Gratis.*

WELDING STAINLESS STEELS is a 64-page illustrated publication covering various types of welding and the effects of heat on different grades of stainless steel. *Allegheny Ludlum Steel Company, Pittsburgh, Pennsylvania.—Gratis.*

INDUSTRIAL SCIENCE LOOKS AHEAD is a 28-page inspirational tabulation of new products and services which the American public may expect in the years to come. The tabulations cover homes, farms, textiles, automobiles, transportation, radio and electronics, and so on. *Department of Information, Radio Corporation of America, RCA Building, New York, New York.—Gratis.*

WARTIME DRIVING TEACHER'S MANUAL is a 184-page booklet designed as a guide for pre-induction and wartime driver education courses. It covers: The driver, driver and pedestrian responsibilities, how to drive, and so on. Available through local AAA Motor Clubs or from *The Traffic Engineering and Safety Department, American Automobile Association, Washington 6, D. C.—Gratis.*

THE TOCCO PROCESS is a 32-page illustrated booklet describing in detail this process of induction heating for the treatment of steel parts. Equipment employed and typical applications are shown and described. *Tocco Division of The Ohio Crankshaft Company, Cleveland 1, Ohio.—Gratis.*

ELECTROMODE INDUSTRIAL UNIT HEATERS, bulletin No. 65, describes the construction, operation, and application of heaters suited for heating isolated buildings, offices, or other spaces where intermittent yet high efficiency operation is required. The heaters are available in either portable or suspension models. *American Foundry Equipment Company, 555 South Byrkit Street, Mishawaka, Indiana.—Gratis.*

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 THIS department in July and August, 1942, data for building a concave grating spectrograph of the Rowland circle type were given by R. M. Watrous. Another form of that type now has been described by Wm. S. von Arx in the *Journal of Chemical Education* (Easton, Pa.) Vol. 19, pages 407-10. As it is the policy of this department to make available to its readers, by reprinting, matter which relatively few of them would otherwise see, the following is extracted from the longer paper. Von Arx, an amateur telescope maker and author of the chapter on Stellar Photography in "A.T.M.A.," originally contributed it to the professional journal named, not in that capacity but in his capacity as a majoring student in science at Brown University. He also drew the sketches. The extract:

There is a new design of grating spectrograph manufactured by Adam Hilger Ltd., of London, under the name "Technal." It has exceptional properties of ruggedness and simple design which are so inherent as to be preserved even when homemade. It is possible to build a modest version of the "Technal" spectrograph in about two weeks of evenings. In no case should the cost exceed $50. Half this amount should be adequate.

First, let it be made clear why the concave grating is preferable to the more familiar prism as a dispersing medium. Prisms introduce irrational dispersion—non-uniform separation of equal wavelength intervals in different spectral ranges—which makes the interpretation of spectrograms unnecessarily difficult for the beginner. Furthermore, the prismatic instrument must always contain three component parts —the collimator, prism, and camera, each of which involves at least one pair of optical surfaces. For analysis in the ultra-violet range, these parts must be made of quartz, which is very expensive. The grating spectrograph, on the other hand, not only produces linear dispersion but may contain no lenses whatever and only one spherical reflecting surface if the concave grating is employed. With these, an aluminized reflecting surface is all that is required for efficient operation in the ultra-violet. This simplicity carries a twofold advantage; it reduces the initial cost of the instrument and makes it easier to keep in adjustment. Another advantage in the use of grating dispersion is the wide range of dispersions available in the higher orders of spectra. While the intensity of these higher orders is usually considerably less than that of the first order, the high intensity of the carbon arc, which is almost invariably used for qualitative analysis of non-conducting samples, allows them to be used for more precise analysis of the complex spectra characteristic of the transition group of elements. The concave grating does possess a few disadvantages, the worst of these being astigmatism. But this can be effectively controlled either by means of properly designed slit illumination systems, or by employing the minimum astigmatism mountings, of which the "Technal" is an example. These reduce the stigmatic error to such a small figure that it becomes unimportant in the normal working ranges.

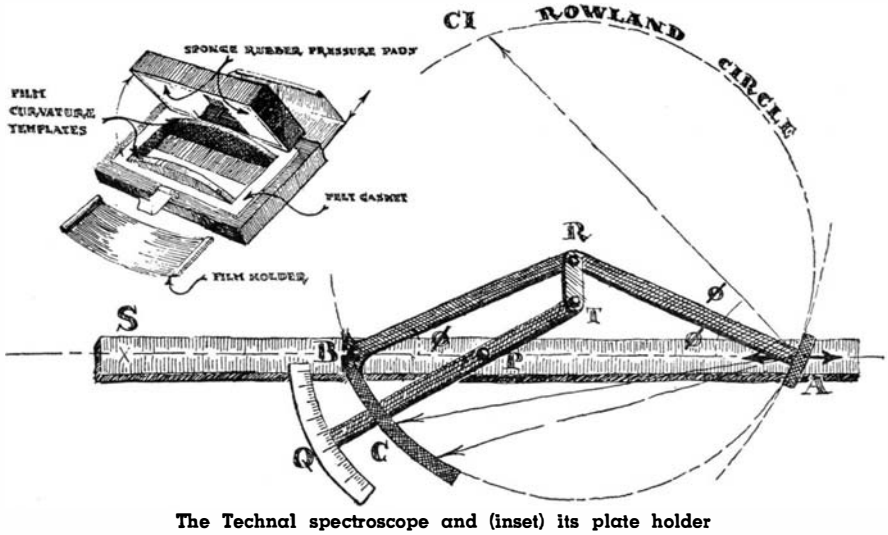
The "Technal" design has no inventor's name associated with it as yet, but J. S. Dowell, of Adam Hilger, Ltd., has described the mounting and the Hilger interpretation of its design, which he credits to Cotton and Richards.

The mechanism involves only three levers of fixed length, a pivoting hinge, and a short track along which the grating moves under control of the lever system. The arrangement of parts is shown diagrammatically in the main sketch, the grating being at *A*, the slit at *B*, and the plate at *C*. The line *BA* represents the center line of the spectrograph bed and the levers *BR* and *AR* are in length one half the radius of curvature of the grating and have the grating and slit-plate elements rigidly fixed to their ends. Where they meet at *R* they are pinned together so as to articulate. A track which is parallel to the bed *BA* is placed under *A*, and is long enough to allow the grating element on the radius arm *AR* to travel along the bed *BA* in the direction of the double-ended arrow for a few inches.

It is evident, since *BR* and *AR* are radii of the Rowland circle of the grating, that by moving the joint *R* toward or away from the line of the bed *AB*, the range of wavelengths recorded on the plate *C* will change. Furthermore, the parts will always remain on the circumference of the Rowland circle and will therefore be in correct focal relation to each other at all times. If a light source is located at *S* on the line of the bed *AB* prolonged, the incoming light-ray must always fall fully upon the grating at *A* no matter what wavelength range is being photographed. If *R* is moved away from the bed it will be found that the plate will record the longer wavelengths or higher orders of dispersion of the grating since the central image *CI* of the slit is on the opposite side of the radius arm *AR* at an angle 2Φ with the bed. The angles Φ are all equal, as is evident from the geometry of the mechanism. They usually have values ranging from 0 to perhaps 10 or 12 degrees.

The angles Φ are varied by moving the joint *R* from outside the instrument by means of the lever *QPT*, which is pivoted on the bed of the instrument at *P* and connected with the joint *R* by a short toggle *RT*. The pivot is somewhat nearer *T* than *Q* in order to provide a small mechanical advantage and greater precision of motion of *R*. The outer end *Q* of the lever sweeps a scale upon which the wavelength ranges for each setting are marked. Not more than half a dozen standard settings need be marked upon the scale. They may be determined by experiment. It is evident that, once adjusted, the entire optical system is completely controlled by the motion of the lever *QPT* and with complete assurance that all optical parts are properly oriented with respect to each other for perfect focus.

All images formed by a concave spherical surface suffer astigmatic distortion except that one image which falls exactly in line with the light source. Astigmatism increases slowly at first as one travels from this point in any direction in the focal plane, but increases rapidly beyond angular departures which are in excess of a very few degrees. Those lines nearest the slit will



The Technal spectroscope and (inset) its plate holder

be most nearly stigmatic and those farther away will show increasing distortion. It is for this reason that the slit in the "Technal" mounting is placed as close to the ultra-violet end of the plate as possible. Since the far ultra-violet sensitivity of plates is always somewhat lower than that of the near ultra-violet and visible blue it is desirable that no light should be wasted in that region. Ideally, the slit should be placed in the very center of the plate, but this is difficult mechanically and would cause great inconvenience in operation.

For spectrochemical analyses of compounds containing iron or other elements of the transition group which have exceedingly complex spectra, two minimum specifications must be observed regarding the dimensions of the optical system of the spectrograph: (1) dispersion of at least 16 angstroms per mm and (2) sufficient resolving power to separate completely two lines of equal intensity not more than 0.4 angstroms apart. In grating instruments this requires a focal length of about one meter, 15,000 lines to the inch, and a ruled surface at least 30 mm wide. The Central Scientific Company of Chicago sells a Wallace replica grating having these minimum specifications for a little more than ten dollars. These gratings are of fairly good quality initially but may be improved by changing the shape of the factory-made mask to be somewhat longer, thereby exposing more ruled surface and increasing the resolving power, and somewhat narrower, in order to compensate for the irregularities in the collodion replica. The precise shape of the mask must be determined by experiment. It is a long and exasperating job but eminently rewarding in the end.

The slit and the plate holder (inset sketch) are the most difficult parts of the instrument to construct and should be given double their share of careful planning and workmanship. A fixed slit of moderately narrow width is recommended. The plate must be curved to the circumference of a circle whose radius is one half the radius of curvature of the grating—the Rowland circle. The "plates" may be strips of 35mm motion picture film if it is expected that only one or two samples will be run at a time; or 8 x 10-inch cut film sliced down the middle to the standard spectrographic size 4 x 10 if more extensive work is anticipated. On these 4 x 10-inch plates it is possible to record at least 16 well-separated spectra with their iron comparisons. The spectra need not be more than three millimeters high if no comparison spectra are juxtaposed, but should be half again as high with comparison spectra, so that about one millimeter of the end of each line can interfinger with the comparison lines. This simple device increases the accuracy of plate measurement, since lines of nearly the same wavelength are more easily classified as coincident or separate.

The astigmatism of gratings causes the ends of the spectral lines to be ragged in appearance, the brightest line being longest. In order to conserve plate space and trim up the spectra, it is necessary to build an extra slit just in front of the plate in its holder. This slit is at right angles to the principal slit of the instrument and is preferably constructed to have variable width. The slit's function is simply to limit the height of the lines and make their outer terminations sharp. A pair of brass-edged foot rulers is admirable for the purpose. They may be made adjustable by coupling the two at their ends in the manner of the navigator's parallel rule.

The light-tight housing around the optical parts of the instrument may be made of sheet metal or of ply-wood screwed to a light wooden frame. The housing should have a door or hatch in it near the grating end of the case so that the grating is accessible for adjustment whenever necessary. A simple flap shutter placed in front of the slit is a convenient accessory. The plate-holder motion scale will be found to be more useful if it is graduated in metric units. The metric scale of a 6" celluloid pocket ruler glued to the plate-holder track with cellulose acetate cement serves admirably.

The design of the bellows between the light-tight housing and the articulating plate-holder track presents something of a problem. Spectrograph bellows are usually of such an odd size and shape that they must be specially made. Bellows cloth costs about one dollar per yard. Bellows may be installed in the usual accordion pleat fashion built up of two layers of bellows cloth with cardboard stiffening pieces cemented between—rubber cement is recommended—or, since the span is always very short, simply cut to fit the gap and allowed to fold as it will without reinforcement inside. The latter is quite satisfactory for small instruments, the natural stiffness of the cloth itself being sufficient.

When the inner mechanism of the instrument is complete, the entire inside of the case and the parts enclosed should be painted dead black. Ordinary blackboard paint is admirably suited to this job, containing enough varnish to stick equally well to metal and wood. Since the instrument is likely to be used in a dimly lighted room, the outside of the instrument is best painted a light gray so that it is more easily seen. It is convenient to mark the rulings on the plate-holder motion scale with zinc silicate paint to which a trace of a uranium salt has been added. A dot of the same on the plate holder makes it far easier to set the plate holder without turning on bright lights in the room. Should the phosphorescent paint be too dim for ready visibility to those coming in from brighter quarters, a small argon night light may be used to excite the fluorescence temporarily.

END OF extract from von Arx's article. While this presents the main data, readers who undertake the actual job probably should obtain the full paper, which is a little longer and which also describes an accessory called the Hartmann diagram for use in photographing two spectra side by side without moving the spectrograph between exposures.

Von Arx is now at Yale University.

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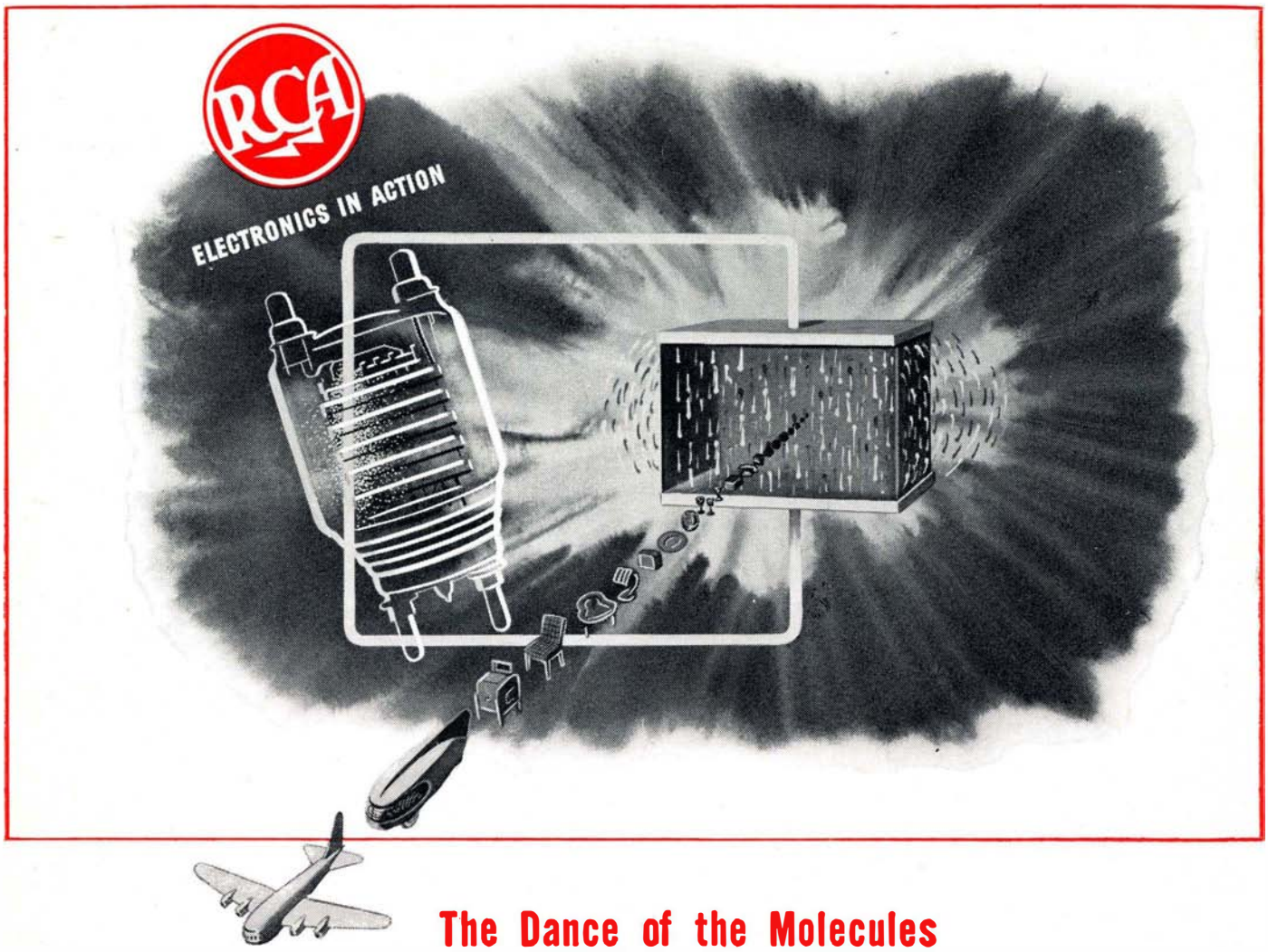

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