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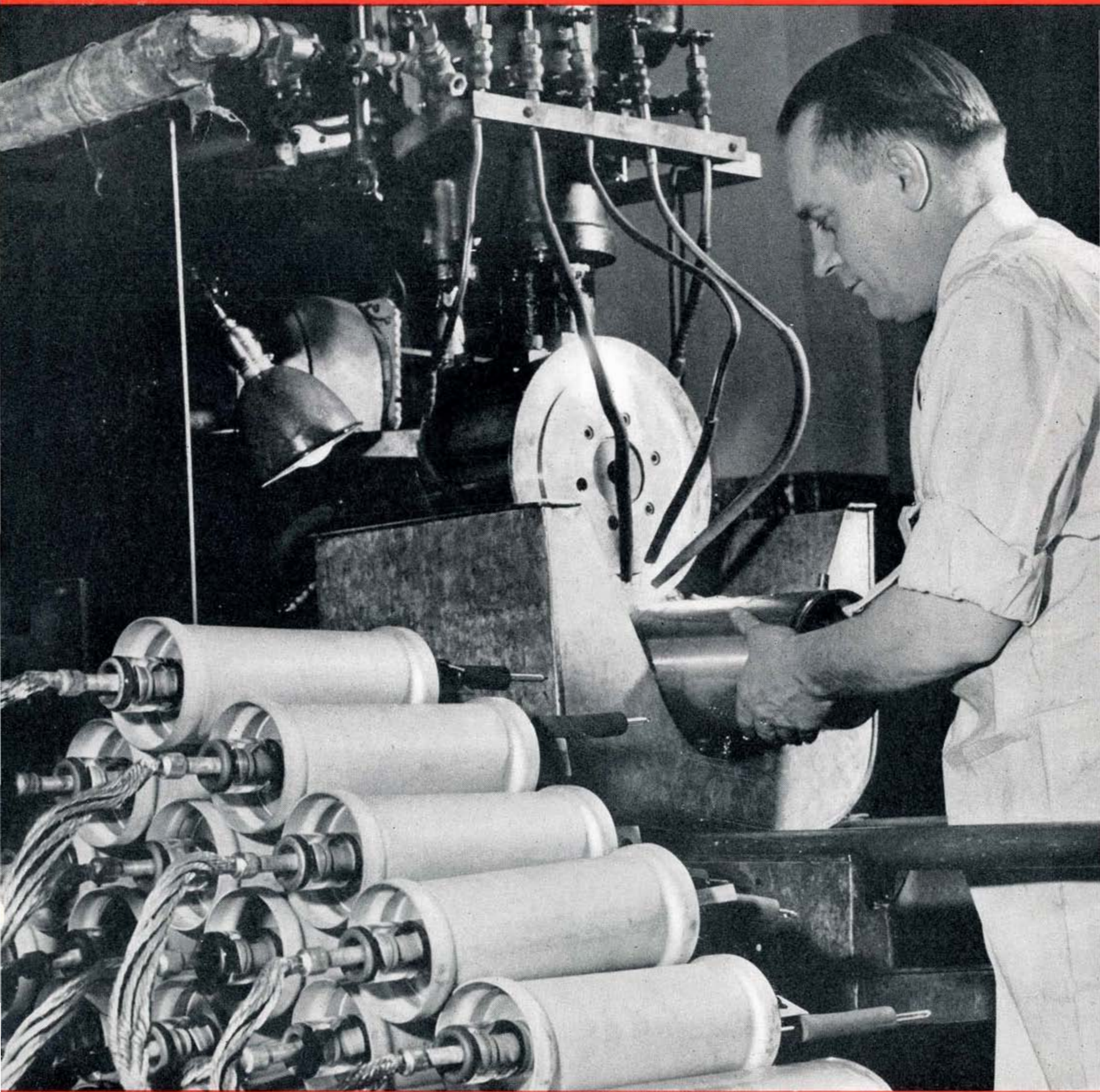
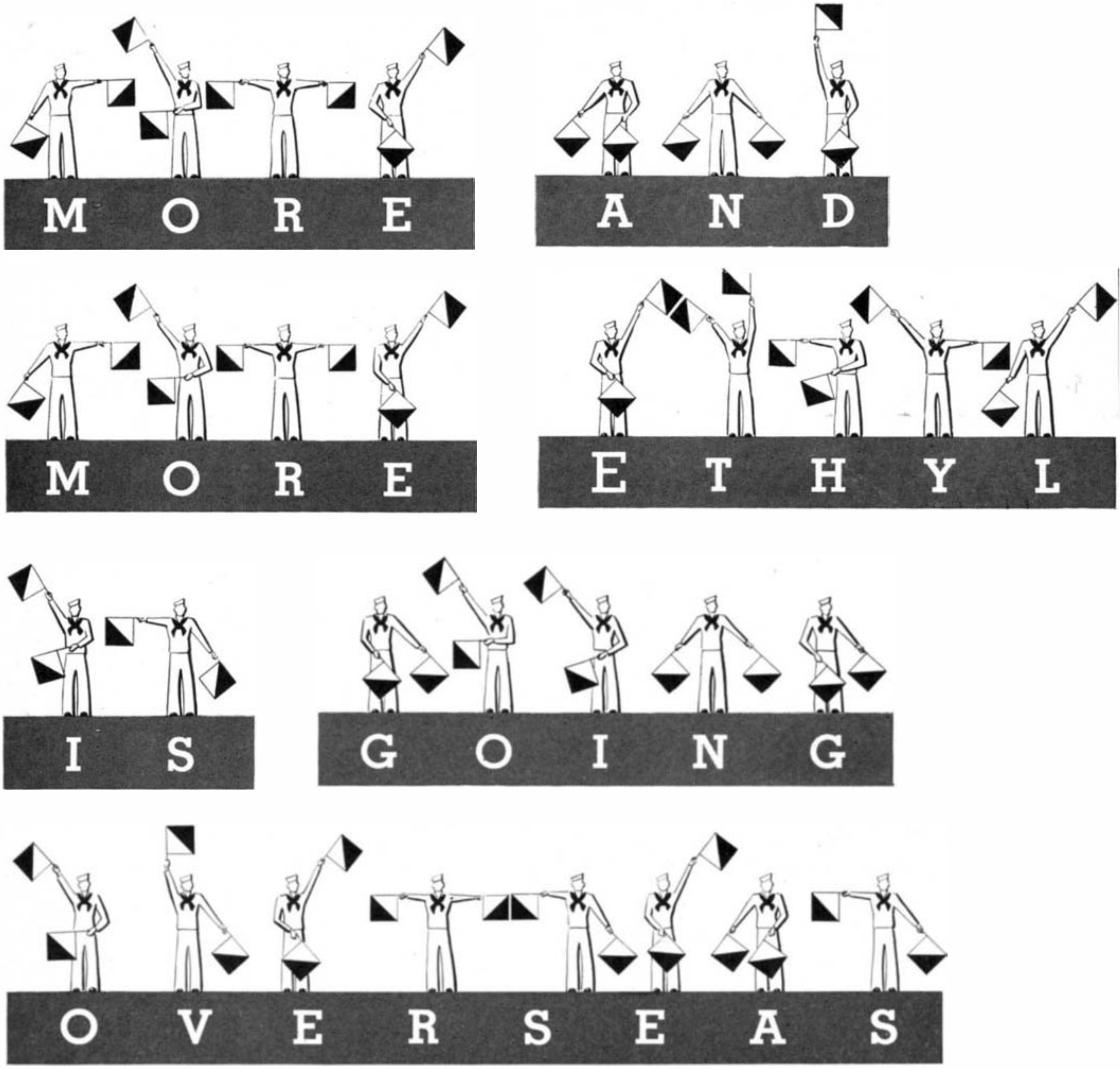
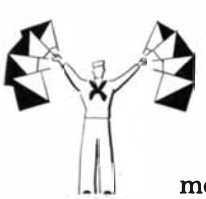


Welding—With Electronic Control... See pages 145 and 157





One thousand 4-engine bombers use about 1,800,000 gallons of gasoline on a 6-hour mission.

That's a lot of gasoline. What's more, the Army and Navy must have *the very best*. For example, every gallon of their aviation gasoline is improved with Ethyl antiknock fluid.

The petroleum industry is doing a magnificent job of meeting the ever-mounting requirements of our own Army and Navy, the British, the Russians and the Chinese. It is to help them meet these wartime needs that government agencies have placed limits on the quantity and quality of gasoline for civilian use.

ETHYL
BRAND OF ANTIKNOCK COMPOUND
ETHYL CORPORATION
TRADE MARK REG. U.S. PAT. OFF.

Ethyl is a trade mark name. It stands for antiknock fluid used by oil companies to improve gasoline and is made only by the Ethyl Corporation.

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CONTENTS • APRIL 1944

COVER: Electronic tubes aid in making electronic tubes. The welding equipment shown on our cover, by courtesy of Westinghouse, is being used for seam welding the metal jackets on ignitrons, electronic tubes that convert alternating into direct current. Ignitrons are also used in the equipment itself. An over-all discussion of electronic control in welding processes will be found on page 157.

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Previews of the Industrial Horizon

By A. P. Peck

PLANS AND PLANS

WHO was kidding whom, when broadcasters and broadcasting stations were recently requested to refrain from mentioning post-war planning on the radio? Stated reason was to avoid building up that old boogie of complacency. But since when does planning for the future make one satisfied with the present? Certainly no thinking person—the type in whom rests the future of the world—neglects the present just because he is planning his next steps. It seems to us that lack of planning, rather than planning itself, leads to a mental stage of stultification.

If the naughty words "post-war planning" are to be kept under wraps, if the people of this nation are to be kept in the dark about the future, if the problems of post-war employment are to be ignored until post-war, it all leads up to something like this: OK, let's not make plans. To hell with it. Let's have another depression—the biggest yet.

PRACTICAL PHYSICISTS

DWELLING on the thought that physical science, through pure and applied research, can provide a tonic for the ill of unemployment in the post-war world, Dr. Albert W. Hull, well-known research man, recently made a pertinent statement which we can do no better than quote: "This tonic is new products. New products are resistant to depression psychology, and experience has shown that they can be sold when old products can't. In this way, physicists can contribute to the all-important job situation."

This makes sense. Should this type of thinking be suppressed in order to avoid "complacency"?

FIBERS TO THE FORE

BRIGHT indeed is one part of the horizon for textile users —and that means everyone who wears clothes. Fibers from which textiles are made may be divided into natural and synthetic. Within each of these groups and between individual fibers of both groups there is growing a competitive situation that is bound to be healthy, even though some will assume secondary positions if they do not fall by the wayside entirely.

Cotton and wool, despite the fact that they account for some 90 percent of all textiles, are the two fibers to which the least research has been applied. On the other hand, consider the case of rayon. This fiber, first developed many years ago, has been constantly improved and now stands in a position to challenge many markets formerly closed to it.

In recent years, also, laboratories have put forth a number of synthetic fibers, stemming from such diversified sources as milk, soybeans (more about this next month), wood, chemical combinations, and so on. All of these have received intensive study during the war. The outcome is going to be better textiles for everyone, in greater variety than ever. Which textile fiber or fibers will lead the field will largely depend upon the extent to which science is drawn into the picture by those with the greatest stake in the future.

STANDARDS

THE ACCEPTED connotation of the word "standards" in industry includes accurately defined processes, sizes, qualities, and tests of materials and equipment that have been generally agreed upon by makers, users, and the public as proper and desirable for general use. Upon the basis of standards has been built the whole scheme of mass production. Standards here are generally dimensional, insuring interchangeability of parts. In other phases of production, also, standards have been proved not only worth while but usually invaluable.

Before World War I the desirability of standards in many industries became apparent. Since then they have been evolving to a point where, during World War II, they have come to a high point of perfection. But still this is not enough. When free competition replaces our war economy—and this is the only sane basis for thinking—there will be even more room and need for industrial standards. The many new materials and processes developed during the past few years will need standardization if they are to be applied with greatest effect. Here is a job—no small job—for post-war management.

SYNTHETIC AFLOAT

DON'T LET your thinking of synthetic rubber's transportation horizon be too closely confined to automobile tires, important though this phase is at the moment and for the immediate future. Another form of transportation—marine—will be an enormous field for synthetics. Coolant and oil hoses, packings, gaskets, and so on, will be possible outlets for temperature-resisting synthetics. Fuel tanks—these for motor cars also—may well be made of synthetics of the type used now in aircraft tanks, and with the well-known safety advantages. Vibration-absorbing power-plant mountings will use synthetic rubber as will also various fabrics and decking materials.

CONDUCTIVE RUBBER

RUBBER is usually thought of as an excellent insulator of electricity. Yet, as readers of this magazine already know, it is possible to compound rubber so that it assumes desirable electrical conductive qualities. Greatest use at the moment of these conductive rubbers is in safety applications where the material is used to drain off static charges.

Now comes word that panels of conductive rubber have been successfully used as electrical heating units by applying them to or incorporating them in the walls of rooms.

FOR FUTURE REFERENCE

PLASTICS bid fair to take over a major portion of the button industry after the war. Introduced pre-war, plastic buttons have been widely proved by military usage, will be more colorful and useful later. . . Aluminum will loom large in the packaging field; many answers to problems have already been found, others will follow. . . Helium, industrially important in magnesium welding, is under close scrutiny in efforts to find additional uses. . . Nylon, in other than textile forms, has a bright future. Already mentioned are slide fasteners, switch housings, instrument parts, and other molded objects. . . Potential electric power from Alaskan rivers is estimated at nearly three million horsepower, which can be developed as the industries of the Territory grow. . . Higher speed Diesels, burning heavy, low-priced fuels, are now being built. Super-charged, such units should make great headway as post-war prime movers on both land and sea. . . Continued planning by the railroads for extended use of stronger, lighter metals point toward safer, smoother, faster transportation. . . Cotton continues to benefit through marriage with plastics. Uses of the union range from expanded textile applications to heavy and strong structural boards. . . Whiskey shortage (more about this on page 151) may go hand in hand with bigger and better poultry, pigs, and cows. Increased industrial alcohol demands result in huge volumes of distillers' by-products which are high in food value for animals.

50 Years Ago in . . .

SCIENTIFIC AMERICAN

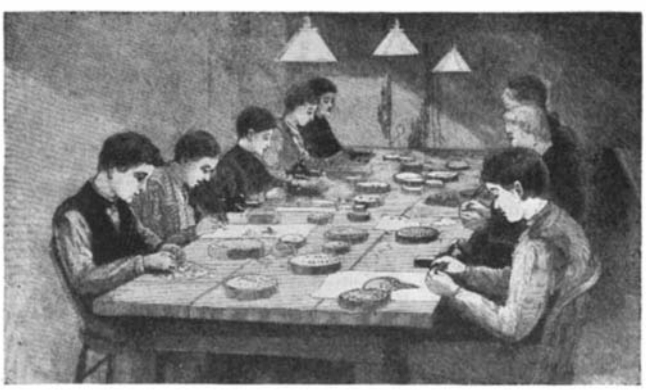
(Condensed from Issues of April, 1894)

ENERGY — "The dynamo of this day presents a very good method of changing the kinetic energies of nature, found in waterfalls, in the winds and in the tides, into heat energy. The trolley railroads exhibit the marvelous adaptability of electricity for the transmission of power."

TELEPHONE — "The telephone is the most wonderful discovery of this half of the century. No invention for that period will compare with it in magnitude, in extent and in the largeness of the business which it immediately began to do, and which hereafter it will continue to do."

INVENTORS — "The subject of the inventor and of how he should be treated by the public is a very wide one, on which different opinions may be consistently or at least honestly held. But the enlightened opinion can be but the one. The inventor should be encouraged. He is one of the few definitely provided for in the constitution, and the patent statutes are built directly on the provisions of that instrument."

CARBORUNDUM — "Carborundum, the new abradent, according to the inventor or discoverer, is the result of both invention and discovery. It was produced after long research



Molding small Carborundum wheels

and careful and intelligent experimentation, and in its production the inventor made the important discovery that carbon and silica would, under favorable conditions, combine to form a definite compound which was hitherto unknown."

UNDERWATER GUIDE — "Mr. Charles A. Stevenson has been making experiments for locating the position of vessels at harbor entrances, which would be of service when, during certain states of the weather, other observations cannot be easily made. He proposes that a cable . . . be laid down in the sea, and, by changing the electric state of the cable, vessels passing near or over it might be able, by means of a detector on board, to discover that they were in its vicinity. Some experiments show the method to be feasible, since the sea offers no insurmountable difficulty, and he has constructed two instruments which will act through 180 feet of water."

SUBTERRANEAN LONDON — "It gives an impressive idea what subterranean London is fast becoming, to learn that on emerging from the river the new City and Waterloo line will, in its passage up Queen Victoria Street, run for a part of the way underneath the low level main sewer, which in its turn runs along beneath the District Underground Railway. So that at this point in the City we shall have first a busy main thoroughfare, below that a steam railway, then a huge metropolitan sewer, then an electric railway, reaching its terminus at a depth of about 63 feet below the streets."

STREETCARS — "Of the seventy-five miles of track now included in the system of The Baltimore Traction Company, thirty-five miles are operated by electricity, fifteen miles by cable, and twenty-five miles by horses."

WINDMILL — "One of the highest windmill towers in this country, if not the highest in the world, has recently been erected at St. James, L. I. . . The tower is 150 feet high. . . The great height of the tower was made necessary from the fact that the spring from which a supply of water was to be pumped was hemmed in by bluffs, and the bottom of the wheel had to be sufficiently elevated to be above all obstructions within a radius of about one thousand feet."

ELECTROLYTIC CORROSION — "Since the introduction of the trolley electric system, considerable has been said and written concerning the subject of corrosion of pipes, etc., by the return current of electricity used in operating the roads. . . . Several plans for correcting this evil have been tried, the best results so far obtained being from electrically welding the rails in sections of about two thousand feet."

EMBOSSED WOOD — "One of the latest machines for doing embossed 'carving' in wood . . . does rapid work. Patterns are cut on a hollow brass cylinder which is heated by gas jets from the inside and the wood passed under it under a pressure of several thousand pounds to the inch in width."

PRESSURE SWEEPING — "One of the most notable of the present century's small inventions is an air pump for cleaning purposes. A hose pipe charged with air under fifty pounds pressure to the square inch is turned upon the article or room to be cleaned. It is used in precisely the same way as the water and hose for washing purposes. It is far more effective in its results than brooms, beaters or brushes, as it searches out and penetrates every crevice and cleft in woodwork. Some years ago it was said that there would never be an invention that could sweep and dust, but at the present rate of things the problem is practically solved."

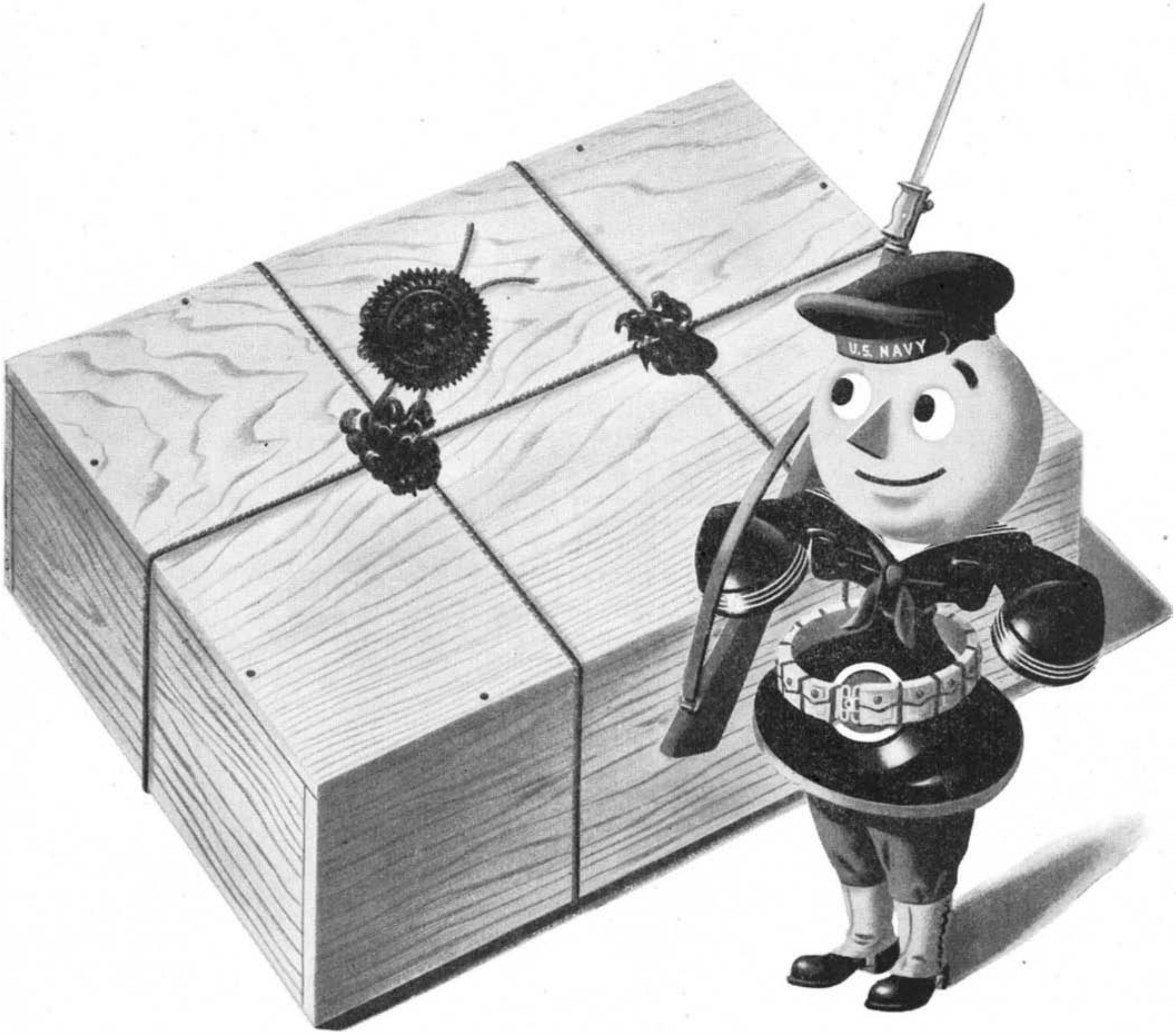
IRONCLADS — "An armored vessel was constructed in the sixteenth century, thus proving that the idea of protected ships is by no means an absolutely new one. This early ironclad was built in the year 1585 by a shipwright of Antwerp during the wars with the Spaniards."

ELECTRICITY IN MEDICINE — "Medical science has called electricity to its assistance in many ways. Various surgical instruments are heated by it; and the use of very small incandescent lamps, which give out practically no heat, permits more extended examination of internal parts than is possible in any other way. The use of the microphone has revealed sounds in the heart, lungs, and other organs which have hitherto escaped the most sensitive ear using the ordinary instruments."

ARCTIC ALUMINUM — "Mr. Wellman's American polar expedition, which is now about to leave Norway for the Arctic seas, makes a new departure in Arctic voyages. Both the boats and sleighs with which the party is equipped are constructed of aluminum, and thereby considerably reduces the weight which the exploring parties will have to carry."

JAPS — "The farmer in Japan who has ten acres of land is looked upon as a monopolist."

TUNNEL — "One of the largest railway iron tunnels in Great Britain, at Glasgow—the Mound North tunnel—goes through a large artificial earthen embankment . . . carrying the national gallery and one of the main thoroughfares between the old and new towns and the work therefore had to be carried out with great care. . . The new tunnel is in effect a huge cast iron tube 17 ft. 6 in. in diameter, composed of segments 4 ft. long by 18 in. in breadth, bolted together through flanges 7 in. deep and 1⅞ in. thick. In cutting the tunnel the shield method was adopted."


U.S. NAVY

"Quotes . . ."

"THE PRODUCTION record of American business during the past two or three years should be a complete answer to those critics, or advocates of a new economic order, who not so long ago advanced the notion that our industrial system is moribund and incapable of meeting the needs of the nation. As events have amply demonstrated, private industry is a very live and potent force, which today is making a mighty contribution to the country's war effort." *Irving S. Olds, Chairman of the Board, United States Steel Corporation.*

" " "

"THE STARTLING forward steps that Edison caused by his own efforts could not have occurred in a totalitarian state, whether the label were that of state socialism or fascism or something else. They could have occurred fully only under the unusual state of circumstances which obtained in this country when Edison worked and created." Vannevar Bush, 1943 Edison Medalist.

" " "

"IN GENERAL, ply separation is the biggest single hurdle tire builders have to take in using synthetic." *William S. Richardson, B. F. Goodrich Company.*

" " "

"IT SHOULD be somewhat of a source of anxiety that whatever the post-war plans made by industry, whatever its miracle production record in the war, the future of business depends on the political and governmental atmosphere in which industry is compelled to operate." Raymond Moley.

" " "

"PROPERLY APPLIED incentives have already increased productive capacity to an unbelievable extent. In those places where labor and management have arrived at an arrangement of complete co-operation, production rates more than four times that in other plants where incentive is absent are usual." *James F. Lincoln, President, Lincoln Electric Company.*

" " "

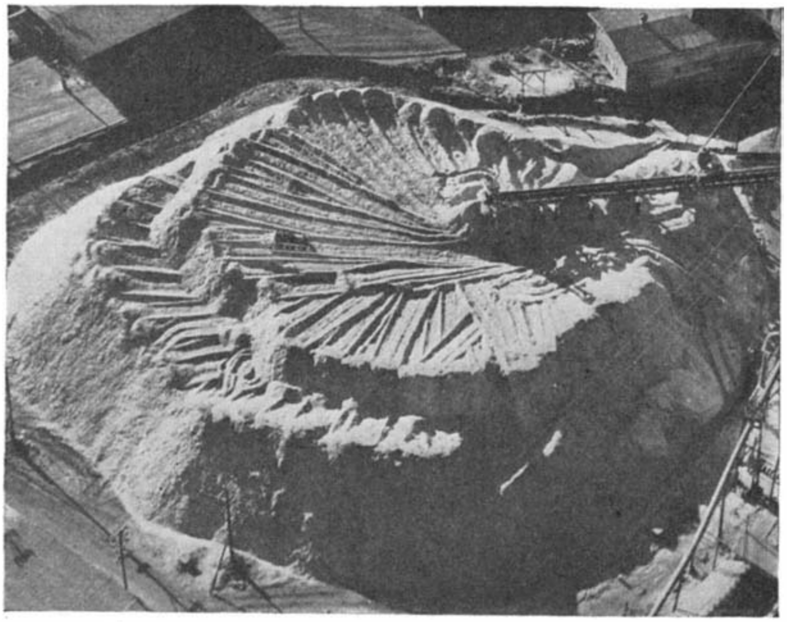
"THE DAY of pioneering in America has not ended. Trail blazing now calls for joint effort by government, labor, and industry. Their authority, experience, and vision must fuse harmoniously to achieve success. There must be but one goal—the welfare of the people and the Nation." David Sarnoff, President, Radio Corporation of America.

" " "

"THE WAR electronics of today, about which as yet little can be said, if given proper encouragement and support, will develop spontaneously into the electronics of tomorrow. It may take 10 to 20 years to utilize fully the discoveries that have been made since Pearl Harbor." *Dr. Irving Langmuir, Associate Director, General Electric Research Laboratory.*

CHEMISTRY IN INDUSTRY

Conducted by D. H. KILLEFFER



The 20,000 tons of sawdust in this huge pile can be made to yield a million gallons of industrial alcohol. Note bulldozer on the pile

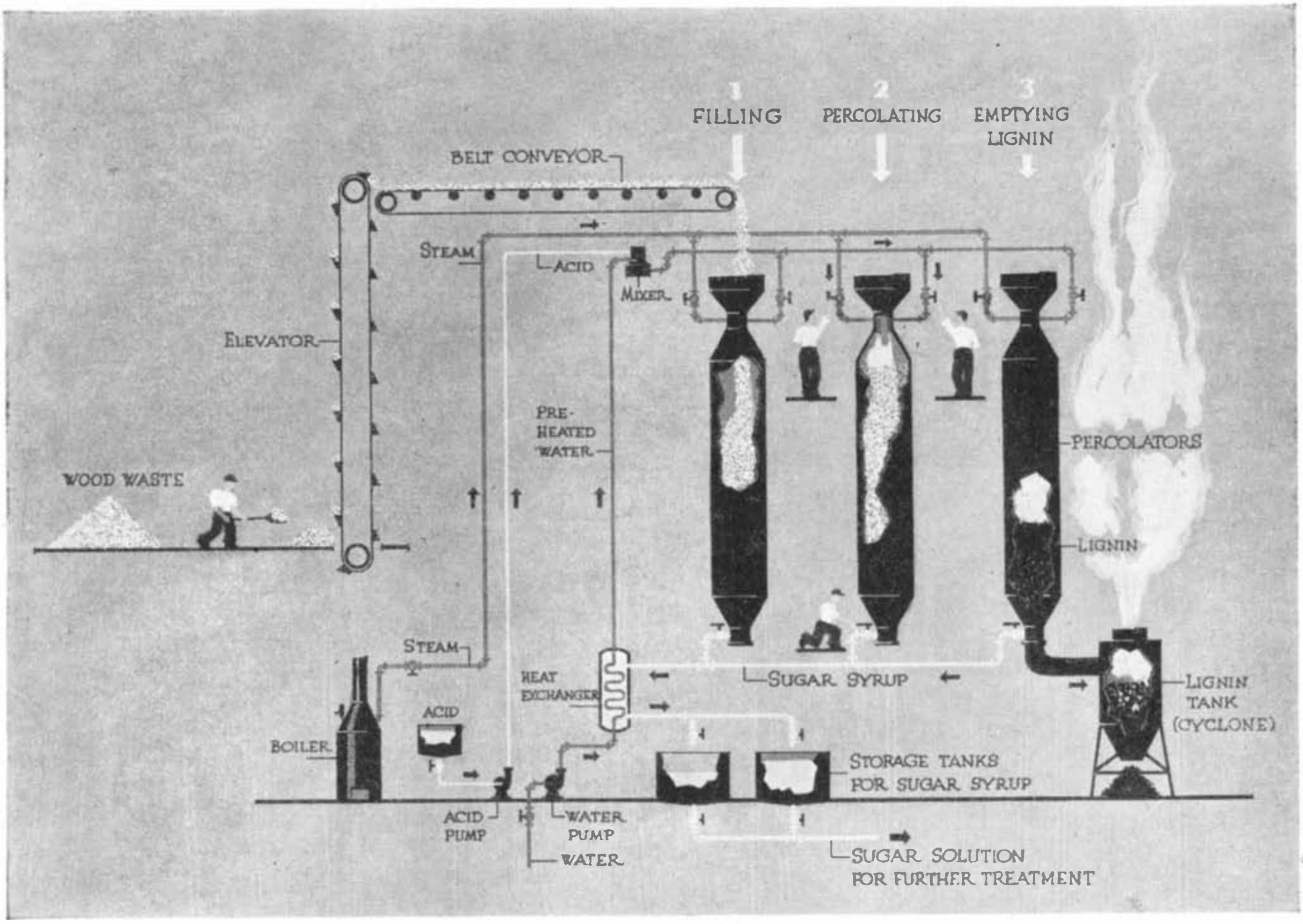
Here's How!

Alcohol Enters So Many War-Needed Products that Present Demands are Six Times Normal Peace-Time Supplies. Conventional Sources are Now to be Supplemented by Alcohol Derived from Wood, Adding New Factors to the Post-War Alcohol-Production Picture

WOOD WASTE may supply the key to the problem of alcohol—grain alcohol—now needed in extravagant quantities to meet the swollen demands of war and of our giant young synthetic rubber industry. Two new developments—new, that is, in America and now soon to be in production—promise cheap alcohol from the sawdust piles of our lumber industry and from the offensive waste liquor from our sulfite paper pulp plants.

Alcohol is the perpetual problem child of industry. With the added complications of war and its immense needs for this useful substance, problems minor in peace undergo tremendous magnification. Interplay of special interests, who find opportunity to forward pet projects in the present turmoil add further to complications. Currently, the most pressing need is to produce quantities of alcohol far beyond anything heretofore contemplated. It is needed to meet the requirements of a mushrooming production of synthetic rubber and at the same time to care for the greatly increased demands that may be considered normal for both military and civilian economies. Proposals shelved or ignored in peace time but of possible value now in contributing to the total output of this essential material are being given large-scale trials to help solve a difficult situation. These new methods, based on utilizing wastes from the lumber and paper pulp industries as sources of alcohol, are being applied on scales which seem likely to resolve all doubts previously entertained about them. They may thus become important factors in post-war industry.

PRODUCTION GOAL SOARS—Alcohol—and by that term is meant specifically grain or ethyl alcohol whatever may be its source—is used by peace-time industry in the United States at a rate of some 100 million gallons annually. Its industrial uses, as distinct from beverage uses, are manifold and may be conveniently divided into three general groups: Solvent applications, in which the extraordinary power of alcohol to dissolve an extremely wide variety of substances places it next to water in usefulness in industry; chemical requirements, taking advantage of alcohol's chemical constitution to produce from it a variety of valuable chemical compounds; and a number of miscellaneous uses. When war struck in 1941, an already enlarged demand for alcohol rose rapidly to an estimated annual requirement of some 350 million gallons. That might be considered a new wartime "normal." Now, the phenomenal development of the synthetic rubber program, requiring alcohol as one of the convenient starting points to manufacture butadiene, has raised the annual production goal to some 632 million gallons. Obviously that quantity is far beyond the range of an industry accustomed to turn out less than a sixth of that amount, and much has been done in the past two years of war to meet this tremendous increase. Part of this has consisted in forcing greater efficiency and output from existing units; a part in building new plants; and finally, as the latest phase of the development, part is to be sup-



Simplified diagram of the conversion of wood to sugar, preparatory to manufacturing alcohol

plied by new processes hitherto neglected.

To understand what has been happening in alcohol, it is necessary to review the industry briefly. Industrial alcohol normally is obtained from three sources: Fermentation of molasses remaining as a waste from the refining of white sugar from cane or beets; fermentation of mashes prepared from the starch of grains and potatoes; and synthesis from the ethylene obtained as a by-product in cracking oil to give higher yields of gasoline.

Molasses has been the principal source of industry's alcohol requirements because it is cheap and plentiful and yields alcohol with minimum trouble and equipment. A gallon of 95 percent alcohol, the normal industrial grade before denaturing, is made from approximately two and a half gallons of molasses at a plant conversion cost of about four cents per gallon of product. To this must be added costs of raw material, of denaturing, and of several other items common to all production methods.

If corn is the raw material, three additional operations are required to convert the starch of the grain into sugar: Grinding, cooking, and malting. These increase conversion costs to about nine cents per gallon of alcohol, quite aside from the cost of the grain. A bushel of corn yields about 2½ gallons of alcohol.

Other farm products and grains can supply the necessary starch, their value for the purpose depending upon their starch content. Grain supplies beverage alcohol but, because the concentration of alcohol for this purpose is only about 50 percent, the distillation equipment of the whiskey industry is much simpler than that with which industrial alcohol plants produce a finished product containing 95 percent alcohol.

Synthesis of alcohol from the ethylene of cracking gases is effected by dissolving gaseous ethylene in sulfuric acid and treating the solution with steam to release ethyl alcohol from the ethyl sulfate previously formed. No comparative cost figures are available but normally alcohol from this source is somewhat cheaper than from others.

WHISKEY INDUSTRY HELPS—The first step-up in alcohol production in 1942 utilized each of these three sources. Molasses supplies were seriously curtailed by the effectiveness of the enemy's submarine campaign. Largely imported from Cuba and other sugar-producing areas, molasses was brought to American seaboard alcohol plants in tank ships, prime targets for submarines. Because the molasses-alcohol plants lacked equipment for handling grain, the initial conversion of the grain to alcohol was largely conducted by the whiskey industry. Thus the whiskey industry could, with existing equipment, receive corn or other starchy grain and turn out 65 to 75 percent alcohol quite readily. This product could then be further concentrated in the more elaborate stills of a few whiskey plants, but principally in molasses alcohol plants, to yield the needed product. In May of 1942 the proposed program was:

Alcohol source	*Annual output*
Molasses	120 million gallons
Whiskey industry, direct from its own stills	100 " "
Whiskey industry, for redistillation	70 " "
Synthesis	60 " "

This represented a reasonably complete utilization of available plants and a corresponding substantial reduction in the output of beverage alcohol. Larger improvement in the import of molasses and expansion of alcohol-producing facilities permitted further increases in the output of alcohol.

The Baruch Committee report on the synthetic-rubber program called for production of a huge proportion of the necessary butadiene from alcohol to be largely made from surplus grain—from a surplus now rapidly dwindling. The facilities of the beverage alcohol industry were commandeered and expanded to even greater production for this purpose. Expected consumption of alcohol for rubber during the present year is more than three times the whole normal peace-time consumption of industrial alcohol in the United States.

That increased demand plus other burdens on alcohol has swelled our 1944 alcohol budget to:

Synthetic rubber	328 million gallons
Direct military uses	48 " "
Lend-lease	59 " "
Indirect military and civilian uses	165 " "
Anti-freeze	32 " "
Total	632 " "

Clearly, such an enormous demand

precludes entirely the diversion of any of the precious product from current production for beverage purposes and requires every possible facility to be fully utilized. What is more important, this extraordinary demand provides a basis for using two sources of alcohol which have hitherto been neglected in this country.

Conversion of the cellulose of wood waste to sugar by treatment with acid, and subsequent fermentation of this sugar to alcohol, was practised in World War I in Louisiana, but the process was abandoned after the extraordinary demand of that war period ceased. Subsequent improvements of the process abroad led to tests on a pilot-plant scale in this country, but not to its adoption on a commercial scale under peace conditions.

The present need for production has ended argument about the economy and competitive position of the process. Consequently, the so-called Scholler-Tornesch process is being installed on a substantial scale for the first time in this country. The operation of the proposed plant will yield definite answers to many questions about it which have hitherto been controversial. Primary improvement is in the method of treatment of sawdust or shredded waste wood with acid. Results obtained with the process in Europe and on a small scale here indicate production of 50 to 60 gallons of alcohol per ton of dry wood substance, compared with 25 to 30 gallons from American practice in World War I. In Europe the food value of yeast, a by-product of the fermentation, possesses a value greater than any yet realized here.

The paper industry has long wrestled with the problem of disposing of the waste liquor produced in the manufacture of paper pulp by the sulfite process. The problem arises because this waste is a serious nuisance in streams and is difficult to dispose of otherwise. It contains the lignin of the original wood, a certain amount of sugar produced from the wood's cellulose content by the action of the acid treating liquor, and a residual amount of the original sulfite acid liquor which goes through the process unchanged. Recovery of the liquor for re-use is impractical because of the high percentage of impurities extracted from the wood. Various proposals to utilize this waste have been only partially successful, but such is the pressure on paper mills to keep this contamination out of streams that a large share of any cost of disposal can be properly charged off to the paper mills' operation rather than to the value recovered.

EFFICIENCY STEPS UP—In the new alcohol projects based on sulfite waste liquor, the acidity of the liquor is first materially reduced by the addition of lime, which precipitates calcium sulfite that can be re-used in preparing fresh liquor. The lignin is next removed and is available as a constituent for plastics or for other use. The residue is a dilute solution of sugars capable of conversion to alcohol by fermentation and subsequent distillation. Improvements lately made in the process increase its efficiency by changes in the methods of cultivating and introducing the yeast required for the fermentation.

Still somewhat problematical is the value of the lignin by-product from both of these processes. Obviously useful, this plastic substance has yet to attain the full commercial stature to which it is apparently entitled. So great is the quantity of lignin available from these alcohol processes that a difference of a cent a pound in its selling price will make a difference of as much as ten cents a gallon in the cost of alcohol.

Both of these processes have much to recommend them. Primarily they utilize waste products which now are nuisances. If they accomplished no more than this scavenging function they would merit serious consideration, but since they also yield a badly needed product their value is immensely increased. Operation on a substantial scale under American conditions will answer questions and clear up reservations heretofore held about both processes. If those answers are favorable, the processes will undoubtedly be operated after the present emergency has passed—may even become important factors in industry. Their promoters are confident of this result.

Prohibitionists delight to see facilities for making beverage alcohol no longer available for that purpose, actually gone to war. Tax authorities worry over a tax to substitute for the one no longer productive on whisky. Industry puzzles over the vexing problems of providing alcohol in quantities scarcely imaginable a few years ago. Synthetic rubber production must have more alcohol. Smokeless powder production requires a small ocean of alcohol in admixture with ether to convert fibrous nitrated cotton to the jellylike mass that is formed into grains for guns. A thousand tinctures, essences, and pharmaceutical preparations consume other quantities of the vital solvent before they can meet medical needs of civilians and fighting forces alike. Motorists need more millions of gallons of alcohol to replace and supplement anti-freeze agents now performing more essential war jobs.

Alcohol is vital for these and all manner of materials and processes bound for war. And war will not wait.

SYNTHETIC MENTHOL

Made from Thymol, A Coal-Tar Derivative

A NEW method of synthesis of menthol, odorous constituent derived from peppermint oil, promises independence from Japanese producers of this useful material. The synthesis requires thymol, derived from coal tar, as the starting material and produces unwanted materials at intermediate points during the four-step process. Each of the by-products can, however, be separated and returned to an earlier stage in the process for reconversion. The final product is what is known as racemic menthol. This differs from the natural product in being a mixture of equal parts of two compounds whose chemical structures are mirror images of each other. Only one exists in the product of the peppermint plant. Both British and German Pharmacopoeias recognize the synthetic compound but that of the United States does not.

FUNGICIDE

Can be Used on Textiles Or on Growing Plants

REPORTED to have high effectiveness against fungi, which cause an annual loss in the United States estimated to be over a billion dollars, a new organic chemical, 2,3-dichloro-1,4-naphthoquinone, is at the same time harmless to plants. The new compound can be used on cotton fibers and textiles to prevent mildew and the accompanying rotting of the fibers, and it is also valuable in combatting the numerous fungous pests and diseases which destroy crops. For both applications it possesses advantages over sulfur and mercury and copper compounds now used for these purposes. Vital, too, is the fact that strategic metals are not consumed in its manufacture.

CRANBERRY WAX

Offers Useful Properties in Emulsions

THE WASTE of cranberry canneries yields a wax, ursolic acid, that is finding wide usefulness in the present period of shortages. Not only is ursolic acid a useful wax, but it is also proving itself as an emulsifying agent in such products as mayonnaise and cosmetics. It possesses the invaluable property of raising the melting point of other waxes with which it may be mixed. The waxy acid occurs on the skin of the cranberry and can be recovered from the waste left from the manufacture of cranberry sauce where this operation is carried out on a large scale.

PAINT IN CRIMINOLOGY

Tiny Flakes Used in Auto Identification

IDENTIFICATION of automobiles as to make and year is accomplished by scientists for the Federal Bureau of Investigation by analysis of paint. Even a tiny flake of the finish from a car often supplies enough evidence for its identification. If this is not possible, at least the number of possibilities is limited to an important extent by the findings. Spectroscopic and microchemical analyses supplement microscopic examination, which reveals the number of coats and mixtures of pigments. Comparison with files of paint samples used on cars of various years, makes, and models frequently completes the identification. Tiny fragments left at the scene of a hit-and-run accident thus may lead, through chemistry, to the guilty party.

Versatile Indium

Once Valued at $20,000 an Ounce, Indium Now Sells for $7.50. It's Peculiar Properties Open Wide Fields of Use in High-Speed Bearings, Solders, Jewelry, and as a Hardening Element in Non-Ferrous Alloys. Not on the List of Critical Metals

By KENNETH ROSE
Engineering Editor, *Metals and Alloys*

WHEN OUR Army Air Corps pilots fly American planes to meet Hitler's Messerschmidt's and Tojo's Zeros, they depend upon whirling propellers and roaring motors for victory—even for life itself. That they may safely count upon their ships is shown by the results of each day's battles. Yet the endless whirling of the propeller, upon which so much depends, is in turn dependent upon a metal which ten short years ago was still a laboratory curiosity—indium.

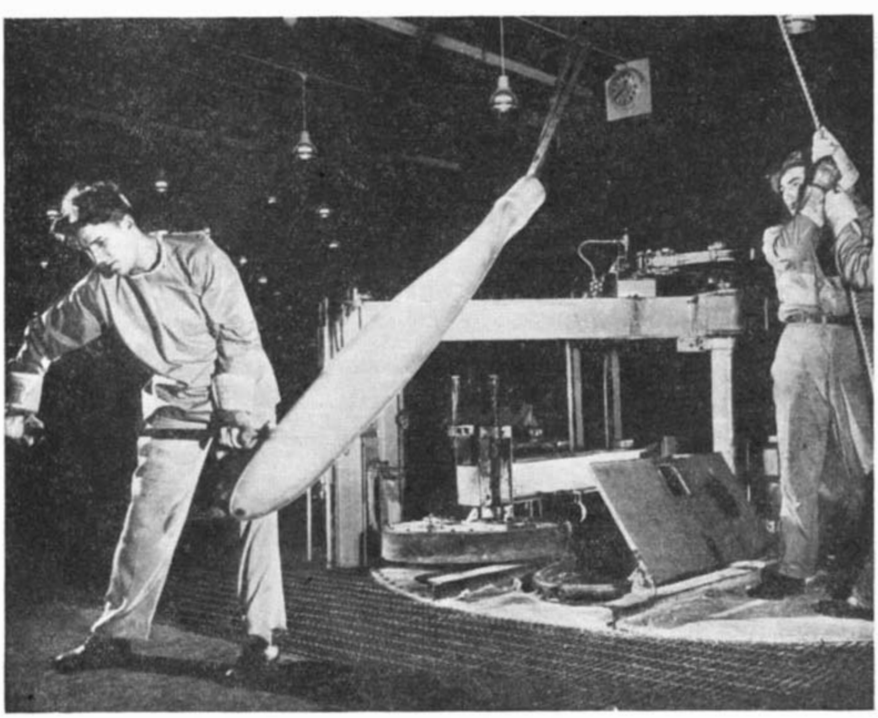
Few machine parts have heavier demands made upon them than aircraft bearings. They must support shafts that transmit hundreds of horsepower at high rotational speeds, with human life in the balance. Yet they must be light in weight, durable, and resistant to corrosion from the lubricant used. The development of the type of bearing now widely used is a story of engineering achievement.

Steel itself would be completely unsatisfactory for any sort of high-speed bearing, but advantage is taken of the strength of steel by using a bearing shell of that metal. The greater resistance to deformation of the steel, compared to the most common bearing metals, permits the use of less of it, thus reducing weight while maintaining the required rigidity. However, the bearing must provide resiliency also, and what better material could be used for this purpose than silver, one of the most ductile of the metals? This silver-steel composite, utilizing the best features of each metal, is being applied to other equipment, as well as to aircraft engines, when a high-duty bearing is needed.

But now another problem appears. Silver, in contact with the moving part, would tend to heat rapidly, also to bind or gall. Another metal therefore is added to provide anti-friction properties, and for this purpose lead is ideal. The lead is electro-deposited as a thin plating over the silver. The result is good, but not quite good enough. The lead film tends to corrode under the action of the acids formed by breakdown of the lubricating oil. For the final touch, indium, a metal softer than lead but more corrosion-resistant than silver, is plated over the bearing surface, then diffused into it.

The resulting bearing, combining the strength and stiffness of steel, the elasticity of silver, the "greasiness" of lead, and the corrosion resistance of indium, has removed aircraft bearings from the list of items which must be periodically replaced in modern planes. A bearing which gave 200 hours of service was formerly considered a good bearing. These new bearings have a service life equal to that of the rest of the motor—thousands of hours.

It might be imagined that the fabrication of this seemingly complex kind of bearing would be a problem taxing the ingenuity of the production engineer, but actually it is quite simple. The steel shell, after proper cleaning, is given a light plating of copper over the surface to be built up. This deposit of copper is not a part of the bearing structure, but merely assists the bonding of the steel to the silver layer to follow. A thin plating of nickel may be added over the copper for some types of bearings.



A modern hollow steel propeller blade undergoing quenching after heat treatment. Many blades of this type are now being indium plated for durability

THICKNESS IS IMPORTANT—The silver is then plated on, the thickness of the deposited layer being a matter of design. Sufficient metal must be laid down to provide resilience, yet not so much that the malleable silver will deform under the thrust of the moving parts. Thicknesses may be of the order of 0.02 to 0.03 inch. A machining operation usually follows, with the internal diameter made slightly oversize to allow for the succeeding deposits.

The silver surfaces are then slightly roughened by sandblasting and a thin film of lead is deposited, again by electroplating. This plate is about 0.001 inch thick, and the plating process may be so controlled that the bearing is brought to exact size, eliminating the need for final machining. If size is not controlled by the plating, a rolling operation follows.

Indium now enters the picture to complete the bearing by conferring its own peculiar properties upon the actual wearing surface. Although indium is softer than the lead plating, it gives greater hardness to an alloy when combined with a number of nonferrous metals. It also melts at a low temperature—only about 100 Fahrenheit degrees above the boiling point of water. It alloys readily with most metals. Taking advantage of these properties, a "flash" plating of indium, perhaps a few hundred-thousandths of an inch thick, is laid down over the lead, and then diffused into the lead plate by heating in an oil bath. The bath is heated to about 350 degrees, Fahrenheit, and the indium, which melts at 311 degrees, fuses and immediately alloys with the surface of the lead. The other metals in the bearing are unaffected by this moderate heating.

Bearings other than this composite are being improved with a coating of lead, followed by a flash plate of indium. Bronze bearings are being produced with a light plate of indium diffused into that metal also. Shortly before the outbreak of the war the automotive industry had recognized the value of indium diffused into the surface of heavy-duty bearings of various types, and the resumption of manufacture of passenger cars and trucks for civilian use will surely see a wider use of indium-treated bearings.

REJUVENATION—Aircraft bearings are now being rejuvenated by replating with indium. For this purpose a wire anode of pure indium is used, the bottom of the bearing is sealed, and the cavity filled with the plating solution. A diffusion treatment follows, and the bearing can be replaced in service.

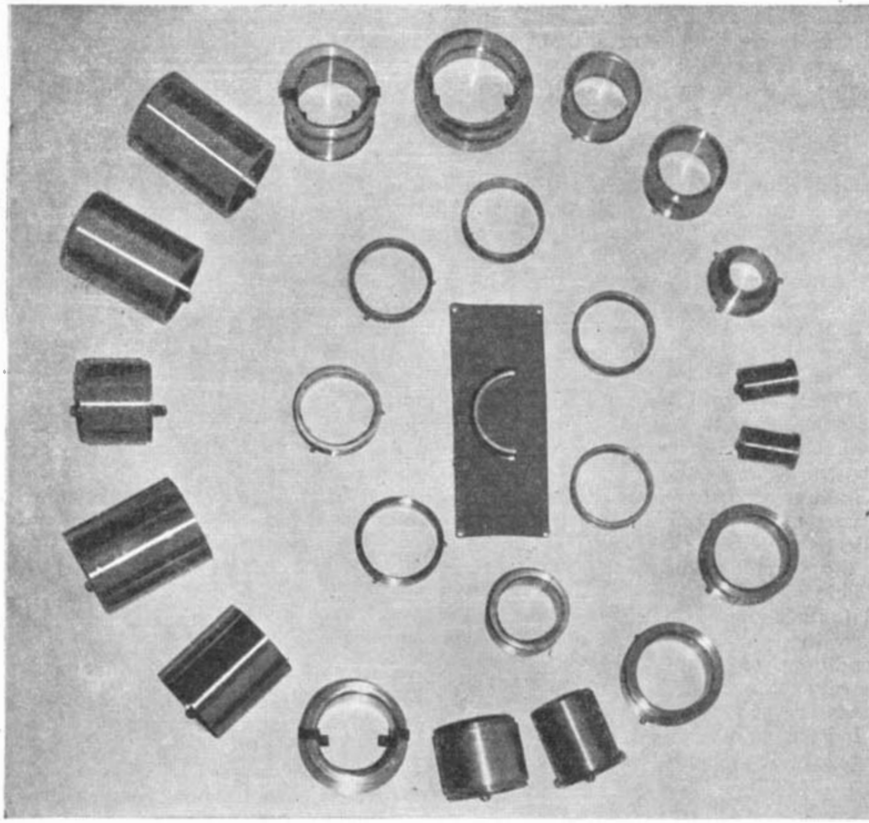
Manufacture of hollow steel propeller blades gave indium another opportunity to serve the aviation industry. Here the problem was slightly different—to produce a coating which would protect the steel and at the same time would not greatly lower its fatigue resistance. Many different kinds of coatings had been tried, but each one either wore through at the leading edge during the whirl tests, and permitted the remaining film to peel, or the fatigue strength of the steel was lowered to an excessive degree.

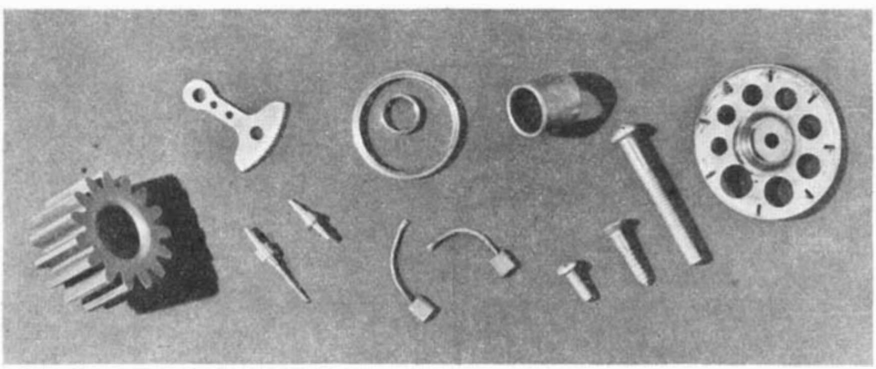
The coating finally developed to meet the requirements was a zinc and indium combination. It was found that this coating, after a whirl test for 4½ hours, followed by a 4-hour salt spray test, showed no trace of corrosion. Fatigue resistance was lowered less than 4 percent. In fact, it was found in long-continued service tests that, even when the coating appeared to be worn away, sufficient zinc-indium alloy had been driven into the surface of the steel to continue the protection.

Production of the coating involves only a careful cleaning of the steel and zinc plating, followed immediately with an indium plate. The indium is then diffused into the zinc film, increasing the adherence of the plate.

These hollow steel propeller blades make use of indium in another form also. Certain brazing operations in the assembly of the propellers employ a gold-indium brazing alloy, prepared for this purpose as a powder. Here again the soft metal indium, alloyed with gold, another soft metal, provides a hard, strong brazing material. Indium also possesses to a high degree that property known as "wettability," so important in solders and brazing compounds.

Wettability makes indium an important ingredient in several soft solders. Compositions of 3 percent silver with 1 to 2 percent indium, remainder lead, are on the market, and show superior properties for some applications. Indium not only wets metals, but glass as well. For this reason the gold-indium alloy referred to before is useful in the construction of several types of electron tubes, in which metal must be soldered to glass. The alloy is too expensive for general soldering uses.





Above: Miscellaneous small bearings are made more durable by indium plating on wearing surfaces. Left: Tarnish resistance is imparted, by the same process, to such parts as small spur gears, instrument racks and pinions, screws, electrical contacts, and so on

An important factor in the use of any material is price. While some metals, because of unique properties, find industrial uses in spite of extremely high cost, the number of possible applications increase rapidly as price falls. When samples of indium were first prepared in 1867, a price of about $20,000 an ounce was placed upon them. Fifty years later the price was still high—$300 an ounce—with no takers. Eight years ago, with industrial applications of indium in dentistry and in jewelry a few years old, and other prospects foreshadowed by research, the price was $30 an ounce. With the coming of the war, and indium's value in aviation recognized, the metal was selling for $12 a Troy ounce. It has achieved the distinction, shared with only one or two others, of two price reductions during wartime. Indium Corporation of America has lowered the price to $10, then to $7.50, a troy ounce, since the outbreak of the war.

ONLY SMALL QUANTITIES NEEDED—While even this price entitles it to a rating with the precious metals, indium has a great advantage in that very small quantities accomplish large results. For most applications a thin film of the metal, perhaps only a few hundred-thousandths of an inch thick, can be plated onto the surface of the work, and this film diffused by low heat. When used as an alloying element, as in solders or as a hardening agent, a few percent will usually be quite sufficient.

It is interesting to note that, while the use of nickel, cobalt, tin, and even copper and iron are restricted, indium is not a critical metal. There exists a potential supply of probably 500,000 ounces per year.

Aside from its present uses in aviation, indium offers possibilities in the jewelry industry. A white gold that is more corrosion-resistant than the present metal can be produced by alloying with a small percentage of indium. Larger amounts produce a blue gold. In both cases a desirable hardening of the gold accompanies the coloring effect. Sterling silver with indium diffused into its surface resists oxidation and sulfation. Other precious metal alloys are known.

Indium compounds are used in preparing the plating baths for these applications. The most widely employed is the cyanide bath, containing indium trichloride, which lays down a good plate under most conditions. It has good throwing power, and has no critical conditions of temperature or current density. Fluoroborate and sulfamate baths are available also.

Indium oxide can be used for tinting glass. Shades ranging from light yellow through deep amber can be produced by varying the oxide content.

Several present important uses of the metal are veiled in military secrecy. Several others are marking time until post-war markets are available. When war-time restrictions upon information and business are ended, indium may be expected to step into the automotive and stationary engine fields and into the machinery and tool industries; to play a more important role in jewelry; to enter the printing trades as a facing for electrotypes; to develop with the solders, brazing alloys, and other low-melting combinations, and as a hardening element in other nonferrous alloys. The price will probably go still lower. Its valuable combination of properties may make it a necessity to some of those new products and tools of which as yet only hints are given. Its future can scarcely be other than bright.

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BROKEN TOOLS

Removed by

Electrochemical Means

One of the most annoying problems in metal-working operations is the breaking of drills, taps, and reamers in such a way that part of the tool remains lodged in the work. Because this situation often means scrapping of the part or the tedious removal of the tool by prying and gouging, the recent development of a quick, automatic, electrolytic method for broken tool removal represents a real contribution to increased production.

The best solution for the removal of steel tools from aluminum castings was found to be a saturated solution of ammonium sulfate in water. The parts may be immersed in a tank containing that solution, the whole metallic system being made the anode in an electrical circuit of 24 to 50 volts potential. Under these conditions the steel rapidly dissolves, but the aluminum quickly receives an anodic coating of aluminum oxide (like the film produced by the commercial anodizing process) and is thus protected against dissolution.

Where batch immersion is not practicable, a special electrolytic apparatus is used by which the electrolytic action will be localized over the area of the broken tool to be removed.

Examination of the resulting hole, bore, and so on, will show complete absence of any corroding effect on the aluminum. Walls will be left smooth and threads intact and bright. All holes will conform to tolerance specifications when gaged.

MICRORADIOGRAPHY

Shows Grain Structure

Below the Surface

Microradiography is a new engineering tool by which the microstructure of metals below the surface can be determined. Its uses are growing rapidly as metallurgists become familiar with its possibilities in telling them things of practical value about the internal structure of materials or parts, incapable of determination otherwise.

Ordinary metallography permits the study of just the *surface* grain structure of metals, and then only after tedious polishing and etching. Ordinary X-ray inspection, on the other hand, provides a means of observing internal inclusions, flaws, pores, and so forth, but not the grain structure.

The technique of microradiography comprises radiographing a specimen of the material on an extremely fine-grained photographic film and then enlarging the resulting image to whatever magnification seems desirable. Ordinarily it is necessary to employ several X-ray tubes, one for each type of alloy, according to the X-ray absorption coefficients of the alloy constituents encountered. R. C. Woods and V. C. Cetrone, of Picker X-ray Corporation, however, have developed a technique that uses a *single* X-ray tube of the tungsten-target type and a variation of the voltage for each situation.

Results have been achieved comparable to those conventionally obtained with several tubes that have to be changed for each job. In addition, extreme flexibility in selecting individual alloy constituents of the metal tested can be enjoyed.

ZIRCON REFRACTORIES

Proved Satisfactory in

Aluminum-Melting Furnaces

Despite the relatively low melting temperatures developed in them, aluminum-melting furnaces present a sizable refractories problem. High-heat-duty firebrick, super-duty and high-alumina refractories fail, even at operating temperatures as low as 1220 to 1300 degrees, Fahrenheit, because of penetration by metal, oxide, or vapor, or a thermit reaction with iron oxides and silica, or mechanical abuse when charging and cleaning the hearth and side walls of the furnaces.

Over the past two years considerable successful experience has been recorded in the use of zircon refractories for the construction of the working hearth in reverberatory or open-hearth aluminum melting furnaces, according to Chas. Taylor Sons Company. Zircon (zirconium silicate) refractories have the peculiar property of not being "wet" by aluminum metal, dross, or oxide. Their apparent specific gravity is 4.46, and thus spalls or small particles of brick will not float in the common aluminum alloys.

In the case, for example, of one ten-ton furnace at an aircraft engine plant, 13.8 million pounds of aluminum were melted on a zircon hearth in a ten-month period with very little erosion and no significant harm to the refractories. The average life of firebrick hearths in this same plant was 10 to 12 weeks, with frequent shutdowns for cleaning and repair.

ALLOY-CLAD

Metal Sheet Presents

New Advantages

The aircraft industry has long used for many exposed surfaces a sheet and plate product (known as Alclad, Pureclad, and so on) consisting of a strong aluminum-alloy core clad with pure aluminum. The pure aluminum surface provides the corrosion resistance and the alloy core the strength and toughness required for such service.

A new product has just been introduced by Reynolds Metals Company that is believed to have certain advantages over the currently used aluminum-clad 24-S sheet—chiefly, superior formability in the annealed and solution-treated tempers and a minimum yield strength 46 percent higher.

Known as R-301, the new material consists of a high-strength core alloy covered on each face with a corrosion-resistant intermediate-strength *alloy.* The material contains the same elements as are present in the widely used 24-S alloy—aluminum, silicon, iron, copper, manganese, and magnesium. This is important since inadvertent scrap admixture of the two materials will thus not lead to serious contamination.

The percentage of alloy cladding will vary with the gage of sheet as protective requirements indicate. Corrosion resistance is of the same order as, although measurably inferior to, the conventional pure-aluminum-clad product.

Unlike the 24-S alloy, the new material can be formed, hammered, rolled, or drawn *and then* solution heat-treated to develop maximum tensile properties in the hardened condition. The higher hardness of R-301 sheet in comparison with pure aluminum-clad surfaces makes it more resistant to the scratches and abrasions that often lead to fatigue failure of the part.

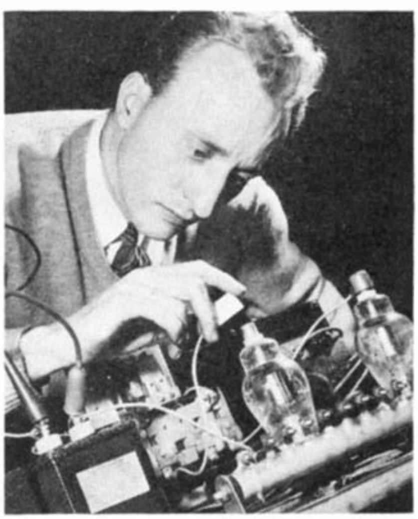
Welding In Production

Electronic Control Methods have Increased Reliability and Speed in Welding, Bringing Precision Operations to the Assembly Line. Factors Governing Quality of Welds Can be Held Automatically Within Predetermined Limits. Magnesium Now Welded Electrically

By VIN ZELUFF
Assistant Editor, *Electronics*

ATTACHING two pieces of metal together without bolts or rivets is an old problem, for a long time solved only by the village blacksmith at the hot forge. Then came oxy-acetylene torch welding and a tremendous increase in welded products, followed in turn by arc welding and electrical resistance welding of the more common metals. Then electronics stepped into the picture and made electric welding a reliable and precision metal-joining process even for structural parts under stress and severe vibration. In addition, metals. Then electronics stepped into welded on a production basis succumbed to the welding process. Today, electronic control has made resistance welding a production-line stand-by and has also aided greatly in arc welding control.

Briefly, resistance welding involves applying pressure to two or more pieces of metal and then heating the surfaces in contact by passing an electric current of a definite value through the joint for a definite length of time. The pressure and the electric current, which, together with the time element, are critical factors in producing satisfactory welds, are applied by means of two copper alloy electrodes or rollers designed according to the type and shape of the material being welded. The amount of current flow is controlled and, when it is stopped, the pressure is maintained until the melted metal sets and the pieces are bound together.



Interior of an energy storage welding control made by Westinghouse and used for welding aluminum parts

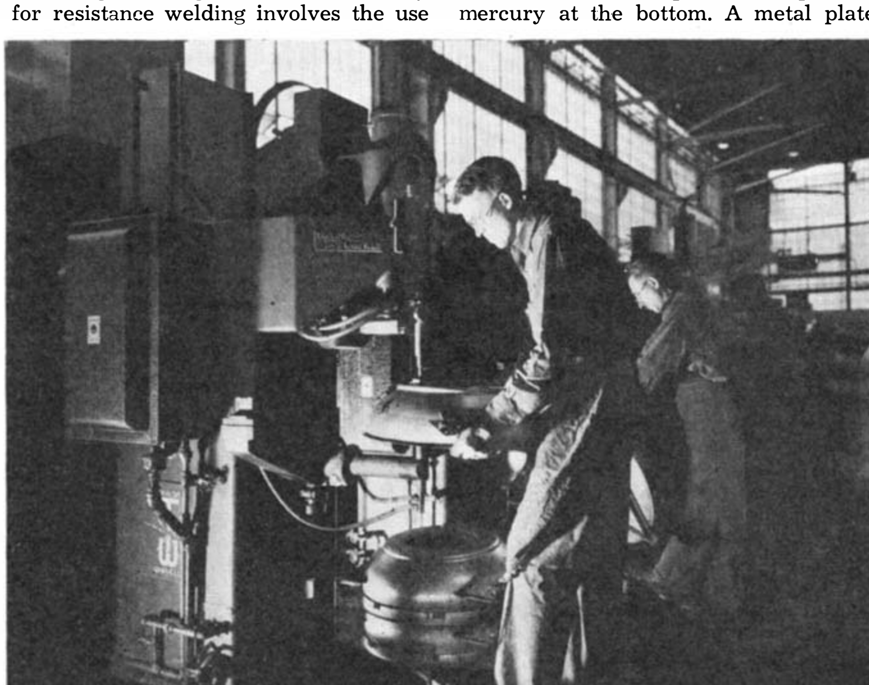
As a metal processing method, resistance welding is not new but it was not in general use until after the addition of electronic control some 20 years ago. Today, the vastly improved versions of electronic welding machines have contributed tremendously to the metal fabrication industries so necessary to the war effort.

To soften metal at the point of contact, the current through the work may be 1000 amperes, a low value, and may be as high as several hundred thousand amperes. The magnitude of the current flow and the length of time of flow are the two important factors that can be controlled by vacuum tubes to determine the quality of the weld. So precise, in fact, is the control permitted by electronics that materials such as aluminum, stainless steel, and magnesium, that never before could be welded, can now be successfully welded on a production basis.

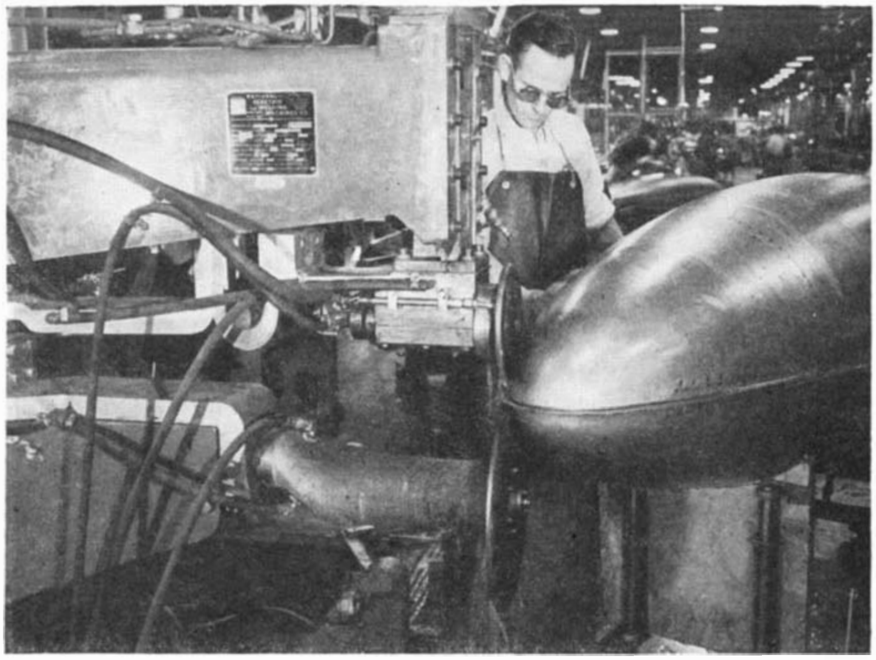
1000 TIMES A MINUTE—One method of obtaining the high current necessary for resistance welding involves the use of a step-down transformer with its primary winding connected to the power line through a current-interrupting unit. This device must be capable of interrupting the heavy current as often as 1000 times a minute without breakdown.

The first electronic interrupters were thyratrons—large glass electronic tubes filled with mercury vapor and having a heated filament. These couldn't handle much current without burning out, hence had to be used in a trick circuit where they shorted the secondary of an extra series transformer in the primary circuit of the welding transformer. After development of the sealed-off, water-cooled ignitron tube—a metal affair that looks like a metal can with a few wires or terminals sticking out—current limitations were no longer a problem.

The ignitron tube consists of a metal container or envelope with a pool of mercury at the bottom. A metal plate



A sequence timer controls current and strokes per minute on this spot-welding job



Two halves of a leak-proof tank being welded at a rate of 60 inches a minute

or anode is suspended an inch or so above the pool, and a special igniter rod dips into the pool. Electrons can flow from the pool to the anode only when an arc is started in some way. An igniter rod does this and does the job so well that the arc is deliberately allowed to go out at each current zero in the A.C. cycle, and rekindled a half-cycle or more later, depending upon how much of the cycle is to be used. The igniter requires only a low voltage and current for this purpose—so low that a small radio-type potentiometer is used to adjust the welding current. Prior to the days of electronic control, huge tap switches were used on welding transformers to adjust the current.

VOLTAGE COMPENSATION—By the addition of other vacuum tubes, electronic resistance welding controls automatically compensate for variations in line voltage and for the amount of metallic material between the jaws of the welding machine. This permits consistent welds to be made by unskilled operators, even though the material varies in thickness or the line voltage fluctuates wildly due to power demands of other electrical equipment in the plant.

For large resistance welders drawing thousands of kilowatts, electronic controls have been developed to operate directly from a 2300-volt power supply system, with resulting savings in copper and in transformer costs.

In welding such low-resistance metals as aluminum and its alloys, the welding current demands are extremely high, and a severe burden is placed on plant distribution systems unless power-factor correction is used. This situation is improved by drawing lower current and storing it over a comparatively long period of time, then discharging it as the required large current in a short space of time. This process is called energy storage welding.

The advantage of energy storage welding is that the power demand is small and is taken from a three-phase line instead of from the single-phase line usually required by A.C. welding. It is used in two forms—one in which a D.C. source (such as a low-voltage rectifier) stores energy magnetically in the primary of a special welding transformer, and the other in which a high-voltage rectifier charges a bank of capacitors. The time required to charge either the special transformer or the capacitors is long compared to the discharge time, and the power demand is very low compared to that required by taking the energy directly from the power line. To obtain the necessary flexibility and preciseness of control, with both methods, electronic tubes are used in the rectifiers and associated controls.

With precision electronic control, resistance welders have produced numerous reliability records. For example, one plant has turned out 21,000 evaporators containing 1,250,000 spot welds, 22 miles of gas-tight seam welding, and 94 miles of intermittent seam welding without a single unit being rejected because of faulty welds. Such production records can be hung up even under such difficult welding conditions as when a large numbers of welders are supplied from a common power line and two or more pull the voltage down by drawing their tremendous peak currents at the same time.

An important electronic aid for maintaining weld quality is a newly developed weld recorder that can be used with any type of welding control. This instrument, as made by General Electric Company, records the variations of the electronic input for each spot weld. When a weld exceeds the safe limits based on predetermined settings of the recorder, a bell gives a continuous audible signal and the welding machine is turned off automatically.

NUMEROUS FACTORS — High-quality welds in resistance welding are obtained by accurate control of electrode condition and cooling, electrode pressure, surface and character of metal to be welded, strength of current, timing of current for each weld, and shape of current wave for each weld. The heat developed in the weld zone, and hence the quality of the weld, is proportional to the square of the current, the resistance of the weld zone, and the time; the electronic weld recorder gives control over all of these variables.

Structural parts that are under pulsating stresses, as in bodies of aircraft, rail cars, automobiles, buses, trucks, and trailers, are being fabricated with greatly increased use of welding. Failure due to a defective weld can be serious, but the increasing use of electronically controlled spot welding, even for structural parts of aircraft, proves the reliability of the method.

Another promising welding development is radio-frequency welding, which is being used in the aircraft industry to weld paper-thin sheet metal to metal structural parts. This process provides air-tight joints with full mechanical strength. It is also being used to weld threaded stud bolts to flat boiler plates,

Spot-welding aluminum parts with a synchronous G-E thyratron control to weld bolts and rods of dissimilar metals end to end with a smooth joint, to weld metals such as magnesium that heretofore were unweldable electrically, and to produce many other difficult welds. Electronic tubes are used here to generate the actual power used for welding, but little has as yet been revealed regarding circuits and equipment because existing equipment is used exclusively on war production.

In this type of welding, practically no heat is produced except at the welding surface. In one test, a thermocouple placed as close as possible to the joint being welded showed a maximum temperature rise of only about 10 degrees. The high current flow takes place for such short intervals that the heat is concentrated right at the welding surfaces where it is needed, and is not conducted to surrounding areas.

Although electronic tube control of welding operations has had to contend with the usual difficulties encountered by radically new processes, its worth in the metal fabrication industries has been tested and proved by the demands of the war-production program. Higher and more reliable weld quality, higher rate of production, reduction in labor costs through the use of less skilled workmen, and the ability to weld materials not capable of being welded by any other means, are factors that industry considers essential for peacetime production progress.

BUMPLESS RIDES

Promised by Development of War Tank Eqnipment

PRINCIPLES that enable American tanks to fire on-the-run with devastating effect quite possibly will provide "floating" rides in high-speed trains and other vehicles, according to Westinghouse engineers. Actual development work on these electronic applications has been started. Calculations show that the power required to stabilize the vertical movement of a railroad coach is only about three horsepower. The servo-mechanism necessary to accomplish this is small enough to fit into an overnight bag.

Curiously enough, the servo-mechanism to stabilize a railroad car will require about the same power and be about the same size as that required for an automobile. The equipment required depends on the weight of the object multiplied by the square of the up-and-down movement of the road. The automobile is much lighter, but the vertical movement is several times that experienced by a railroad car.

OIL HOLE INSPECTION

Checked With Mirror and Photoelectric Cell

THE JOB of determining whether an oil hole drilled longitudinally part way through a shackle bolt exactly meets another oil hole drilled into the bolt from the side is being performed automatically by a machine that utilizes simple photoelectric principles. A beam of light is reflected from a mirror into the longitudinal hole while the bolt is revolved one complete turn by a rubber-tired driving wheel. A phototube is mounted adjacent to the side hole. If the phototube does not receive the required amount of light at that point in the revolution when the side hole is facing the phototube, a rejection mechanism is actuated. Either imperfect alinement, blocking by metal particles or insufficient depth of drilling can lower the amount of light making the right-angle bend through the bolt and cause rejection.

CRANE STABILITY

Assured by Use of New Electronic Gage

LARGE boom cranes that lift heavy sub-assemblies for warships have booms that extend over 100 feet and exert considerable leverage against their mounts. The crane operator, perched in a cab 60 feet high, is constantly conscious of the danger of the crane overturning and must carefully adjust his controls.

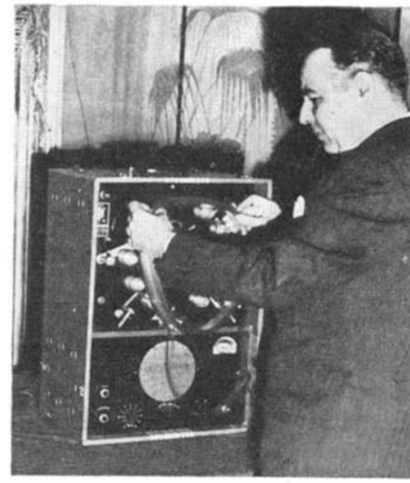
Safety margin in crane operation is indicated by this new instrument

To eliminate this danger, a crane stability gage, shown in the photograph, has been developed by electronic engineers of General Electric Company. The gage provides the operator with a continuous indication of the margin of safety and is arranged to stop the crane automatically if the boom is extended too far or is too heavily loaded.

SOUND ON CELLOPHANE

Eight Hours Playing Time for a Single Table-Model Machine

SIXTY wiggly grooves on a 320-foot endless loop of inch-wide cellophane tape represent eight hours of recording for instant and automatic playback in a new portable cellophane-tape recorder developed by the Fonda Corporation.



Eight hours of continuous sound can be recorded on the cellophane loop being loaded in the recorder

Operating cost for recording tape is at present about 50 cents an hour to the consumer, with promises of substantial reduction when production goes up This figure is extremely low in comparison to other methods of permanent recording.

The problem of pressing a sound track on the tape, which is only about twice the thickness of ordinary cellophane, was solved by adoption of a yieldable felt bed directly under the recording needle. Both the recording and reproducing needles have permanent gem points that do not require changing and produce no shavings. The tape runs under the needle at a rate of about 40 feet a minute in standard models, and has room for 60 parallel grooves without risk of breaking into adjacent grooves. The action is entirely embossing and the pressed-out ridges can be felt at the back of the tape.

Simplicity of operation, low cost, permanence, and ability to identify any portion of a recording by marking directly on the tape with crayon make this an ideal reference recorder for the whole range of industry, from small offices to traffic-control towers at airports and the monitoring of radio broadcast programs. It can be connected to a radio set, program line, or directly to a microphone for recording every spoken word at a conference or interview. No supervision is required during use—simply press one button to start recording, another to stop. Loading the preformed endless tape is simpler than threading a home movie projector.

Quality of reproduction depends upon tape speed. For voice reproduction, 40 feet per minute is adequate; at 60 feet per minute the useful frequency response is extended to 6000 cycles per second, uniform within 2 db. The amplifier and loudspeaker are built right into the portable cabinet.

The standard model, for reference recording, requires attention only three times in a 24-hour day, for changing of tape. A stationary one- to eight-hour unit is available for such permanent applications as at airports, radio stations, and government uses, while a smaller unit recording for up to one hour has promising possibilities for office dictating uses.

Precision for Every Plant

Millionth-Inch Tolerances on the Production Line. Progress in Measurement Methods and Tools Has Been so Great That Even the Smallest Plant Can Afford the Equipment Necessary for Turning Out Products with an Accuracy Undreamed of in Manufacturing Processes of a Few Years Ago

ONLY TEN years ago, 300 leading manufacturers of machinery and machine parts were asked about the tolerances to which they were commonly manufacturing, and whether the trend of their tolerances was toward the coarser or the finer. A full 60 percent of them were working to the order of .001 inch as their finest tolerance, with limits for ordinary work in the .002 inch to .005 inch range; 38 percent had some production work that was held to .0001 inch limits, but such parts were rare; the remaining 2 percent were working to .00001 inch and were inclined to be boastful about it.

On the subject of the trend of limits there was almost complete agreement. All but two said that their tolerances were becoming finer and finer; would become still finer as fast as facilities could be accumulated for making them so. Only one man made any strong plea for coarser limits than the ones to which his plant was working, and it is interesting to note that his company got into financial difficulties twice during the depression although its competitors were making money.

The trend toward finer production limits accumulated force like a gathering tornado during the depression. It was destined to blow old-fashioned production methods off the map; make possible such devices as the synchro-mesh transmission and the Wright Cyclone aircraft engine—among thousands of others. On its further development depends the oncoming $2,500,000,000 market for frequency modulation radio sets (25,000,000 sets at a minimum of $100 each), the equally big market for television, the lighter but much stronger automobile, the family "flivver" airplane, and all the other devices which must be manufactured if people are to make their living after the war.

CLOSER TOLERANCES COMING—Only yesterday a limit of .00001 inch for production work was regarded with awe and was to be attempted only by men of the highest skill. Today, companies like Browne and Sharpe, Pratt and Whitney, L. S. Starrett, and George Scherr are turning out gages to measure to this tolerance as ordinarily as they might make gears or slide rules, and the crudest of labor can use these gages with very little training—the way such gages come flooding back to their makers for repairs shows that the labor using them is crude indeed. And in the very near future, tolerances of .000001 inch (yes, one millionth of an inch) will be out of the realm of the metallurgical laboratory or the tool room and into that of the ordinary production line. Many plants talk in millionth-inch terms right now, but the rarity of this fine tolerance is shown by the fact that, although square and flat gage blocks are among the simplest of millionth-inch-accuracy shapes to hold true, only eight factories in the United States are attempting to make them.

Tests of surfaces with an optical flat show bands such as above if the surface is not true, but bands as below if it is practically flat

In spite of all that special machines and methods can do to control precision production, fine tolerances seldom can be held by workmen who do not understand the dignity and importance of what they are doing. So great is this problem that it might prove insoluble if it were not for the fact that fine tolerances attract fine workers. And since it takes high-grade managements to handle high-grade men, the effect of this situation upon management personnel is drastic. The tough talking, tobacco chewing foreman is gone with the cow-boy and the "Bull-o'-the-Woods" plant superintendent; in his place is the college trained man who depends upon superior technical ability to hold the respect of his men.

First step in the teaching sequence usually is to compare a fine dimension with the classical "fineness of a hair." Since the average human hair is .025 inch thick, it follows that 2500 tolerance areas of .00001 inch would have to stand on each others' heads to equal the thickness of a hair. This is something which impresses the new worker, and with which the old hand never ceases to impress his neighbors who pound typewriters or earn their living in other crass ways. It adds to his community social standing and to his pride in his job.

Second step is to demonstrate—and keep on demonstrating—the absolute cleanliness without which fine tolerance manufacturing is impossible. In terms of cleanliness this type of production yields nothing to any hospital technique, although the hospital pays more attention to antiseptics and the factory to temperature; the constant temperature rooms of more than one factory would compare favorably in cleanliness with many a hospital's operating room.

APPEAL TO HONESTY—In time the worker learns that any dirt around him, or dirtiness in his work, will show up as falsely finished parts or badly damaged instruments and machines. Add to this the appeal to his innate honesty—the fact that it is impossible for the fine-tolerance worker to conceal his mistakes and that only such men as do not attempt to cheat will continue to work beside him—and a man mentally gaited to fine limit production has been produced.

Close limit production would not progress very fast if it were inconvenient to achieve—if it could be had only in plants making large numbers of duplicate parts and having fat wallets with which to buy special equipment. On the contrary, it is largely because it is becoming more and more simple and convenient that precise production is coming along so rapidly.

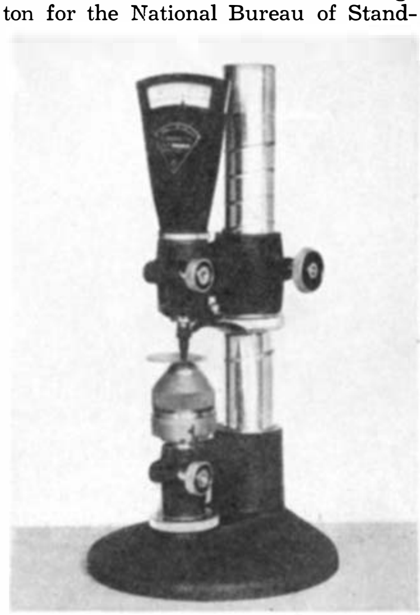
The magnetic chuck for grinding machines and for light duty lathes and other machines, for example, was well known during World War I. But permanent magnets made of such materials as Alnico, strong enough to hold 30 times its own weight, are relatively recent developments. They can be used almost anywhere; they need no wiring up for current.

Convenient also are magnet blocks, consisting of alternate layers of brass or other high conducting metal and highly magnetic irons. Before these came into general use, any magnetic chuck to be used for thin or especially accurate pieces had to be ground and trued up continually, a time-consuming operation which wore out the chuck with undue rapidity. But the magnet blocks can be placed on any magnetic chuck, and the blocks themselves ground or otherwise trued up. Often they are recessed or ground to special shapes. The holding power of the blocks is nearly equal to that of the chuck itself, while the wastage of time and of chucks is negligible.

Distortion of accurate parts and of the gages with which to measure them, once was a problem requiring time, patience, and money to solve. But distortion-resistant irons, largely based upon the researches of the International Nickel Company, are today quite common and inexpensive. And alloys like Invar, which changes dimensions less than one tenth as much as ordinary steels, under the influence of temperature changes, are available everywhere.

LOWER COST—But perhaps the greatest factor in the convenience of accuracy, is the reduced price and the increased availability of the ordinary gage block.

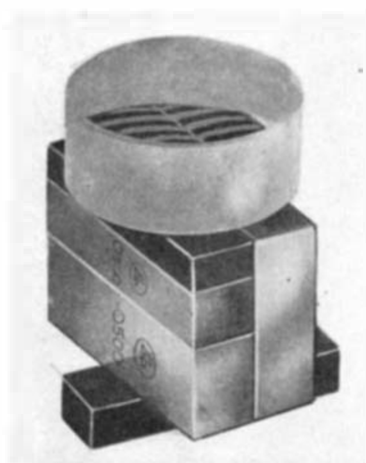
The gage block idea goes way back into the dawn of modern mechanical history. Standard inches—they differ slightly in size—exist in Washington, D. C., and in London, England. Both of them are based upon the standard meter which is—or was—a bar of platinum-iridium at the International Bureau of Weights and Measures in Sevres, France. (The original block's existence is no longer important, for a meter can be created in terms of light waves, being 1,553,155.72 wavelengths of the red radiation from cadmium, or 1,770,039.01 wavelengths of the yellow-green radiation from krypton, or 1,993,738.86 wavelengths of the green radiation from helium at 20 degrees, Centigrade, 760mm barometric pressure, and 10mm vapor pressure.) But not very long ago any mechanic who wanted to have his gages checked had to send them to Washington for the National Bureau of Standards in order to have the work done.



A radio quartz crystal, only .030 inch thick, being gaged between a flat spindle and spherical anvil

When Johanssen first started producing gage blocks in the United States, they cost $2000 for a small set. Such blocks were like jewelry. The average mechanic knew about them and could discuss them on about the same basis that the average housewife knows about the goings on at the Stork Club. But now sets of 81 blocks from which more than 120,000 combinations of dimensions in steps of .0001 inch can be made are available for less than $500; 34-block sets capable of 80,000 combinations cost less than $300; a nine-block set capable of 300 combinations is cheap enough so any mechanic who can afford good micrometers can afford the blocks to go with them.

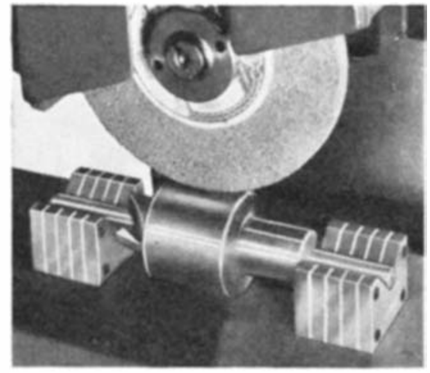
At such prices, gage blocks made to accuracies of a few millionths of an inch are put to hundreds of uses. A few: Check "go and no-go" or snap gages, check micrometers, set up sine bars accurately, set height or depth gages to finest accuracy, set up machine tools, locate holes for jig drilling and boring, set depths of cuts on shapers or on milling machines, check the settings of positive stops on lathes.



The light bands seen through the optical flat show the accuracy of the surface of the gage blocks

Where a few years ago the average tool room man knew only by description that he should wipe the oil off gage blocks, rub them against the backs of his hands for a little lubricant, wring them together so that their edges meet exactly, wring them apart after using, clean and oil them before putting them away — he hoped some day to try this at a machinery show or somewhere — now such operations are daily routines in even the smallest of high-quality machine shops. And with them has come accuracy as a commonplace.

With the gage block has come the use of light waves for checking the flatness and the parallelism of surfaces. Not so long ago a mechanic who had just trued-up his micrometer would be likely to bring the spindle down to the anvil, hold it at eye level, and if he could not see daylight between the two parts, he would assume that spindle and anvil were square with each other and neither concave nor convex. Now he brings spindle and anvil against the faces of an optical flat — a piece of special glass with its top and bottom planes lapped precisely parallel — and looks at the light bands which he can see through it. If these bands are true, evenly spaced, and straight, then he knows his surfaces are flat and parallel. But if the bands are distorted, circular, or vary in color, then the surfaces are not parallel or are not flat—the colors and patterns of the bands tell the whole story. A second optical flat of slightly different thickness than the first is used for a second checking, for if the mike were tested at only one setting the anvil and spindle might be in true alinement at that position although at no other.



Magnet blocks make for accuracy

BETTER MIKES — Because micrometers can be checked so accurately and easily, a change has been made in the thinking about them. Once it was considered that, although any mechanic might measure to .001 inch with a micrometer, only an expert could be sure at .0001 inch — a false sense of touch or "feel" would throw the less trained man off. Many micrometers then did not even have the ten thousandth of an inch vernier scale on them. But now it is believed that a reasonably trained man can measure to a ten thousandth if the mike is right. Many authorities consider the micrometer which will not measure to a ten thousandth to be obsolete in any size less than three inch. (Above three-inch the heat of the hand will itself throw the tool off more than a ten thousandth unless it is handled by a man skilled enough to avoid this.)

Such trust in accuracy is important. For micrometers are still the most needed tools for fine measurements — they are the infantry of accuracy.

Rapidly developing, also, are the instruments which throw shadows of parts to be measured upon ground glass or other screens. Wherever contour is to be gaged, these are making rapid strides.

One of their great advantages is that a permanent record can be made of the story they tell. With a piece of paper laid across the screen, the silhouette made by any coutour may be traced with a pencil. In some cases a photographic film is laid on the screen and direct exposure made. Such records show exactly what is wrong with a production machine set-up and thus cut down the highly expensive set-up time, or show how rapidly cutting tools are wearing and thus give warning of the need for sharpening and replacing them, and the like.

Shadow instruments, with others, also

are being used to speed the developments of new products. Everyone knows that two boats — or two automobile engines—may be made as nearly alike as human ingenuity can contrive, and yet one may run much better than the other. In modern experimental departments the superior product is taken apart and every dimension and contour on it is traced on the shadow screen, in-

Checking a mike optically

terior surfaces being followed by mirrors. The same treatment is given the inferior product, and all contours carefully compared. In case after case, this method discloses the secret of superior performance — a secret that "trial and error" might need years to find.

The onward rush of accuracy is in materials, men, and instruments. Except for one point, no one knows exactly what the post-war product of any machine shop will be like. That one point is: It will be made to tolerances little dreamed of in the pre-war days.

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FOREMEN

Are Being Recognized as

Most Important in Factory

No matter what anyone may think of foremen joining labor unions and thus calling themselves part of the labor force instead of representatives of management, when organized foremen pulled strikes in middle western plants recently the value of foremanship was proved as never before. Production decreased to the vanishing point.

One quick and direct result of this realization was the setting up of dozens of plans for giving special incentives to foremen. Forward-looking companies like Caterpillar Tractor and Lincoln Electric had done this years ago. Now the practice promises to become as wide as all industry.

A drop-forging shop in New Jersey intends to give forge room foreman bonuses based upon the metallurgical results in the parts which come from their hammers. A plastics shop will pay foremen extra wages if absenteeism and labor turn over is low in their departments. A cotton mill will tuck a little extra into the foreman's pay envelope if the call for repair parts to the machines under his control goes down. And a printing press manufacturer gives rewards if the spoilage of parts is less while production speed stays up.

These and other plans show that the foreman is being recognized for what he is—the most important man in the factory.

CLEAN PLANTS

Make Possible

Precision Production

The spotless house-keeping of modern factories is one of the miracle producers of this war. It makes the modern accuracies practical, is one of the factors without which they would be impossible.

It takes an old timer who is thoroughly familiar with old style methods to appreciate just how far this cleanliness goes. Many a youngster, just cutting his industrial teeth, does not realize the extent to which dirt once was taken for granted.

A flight control instrument is taken apart at the plant of the Minneapolis Honeywell Regulator Company. As casually as if they were in their own homes or clubs, executives lean their light-colored coat sleeves on benches and a Navy man takes the instrument apart without bothering to cover up his uniform. There is no excess oil about, no grime.

A white smocked inspector leans over a telescope through which he is checking the calibration of an anti-aircraft gun sight aimed at a fixed target. The slightest dirt would show up on that smock and be a warning that the clean-up gangs had better get busy and the operators be more careful.

Dressed in light colors, a spray-gun operator performs what used to be one of the most soiling tasks in the plant. Spray painting is done right in the middle of production lines now; it used to be relegated to special rooms where its fumes and splashings could not do damage to other operations. Evacuation from the cabinet, size and shape of the spray stream, and pressure

No excess oil . . . no grime

The smock serves as a dirt tell-tale

of application, are so well controlled that the operator will leave his shift as clean as he came on it.

Perhaps the best demonstration is an operation like the grinding and polishing of the insides of glass tubes. Here the operator wears oil-proof gloves; she must apply extremely fine rouge with a paint brush to moving parts, and it will get on her hands. Her smock will get a little dirty too where she rests an idle hand against it. But there is no soil on the front of her; her bare arms and face are not spattered, for the operation is too cleanly controlled for spattering.

Millions of operators trained to the cleanliness of modern plants will go home desiring clean machinery that is easy to keep clean, and this inculcated taste will be one of the big factors in the post-war markets of American industry.

SPECIAL MICROMETER

Used to Determine Hardness

Of Plastic Stock

The screw-thread principle of the micrometer is being applied in dozens of special ways, many of which are based upon modifications of standard micrometers.

One type of plastic, for example, is extruded into round bars and then put aside for seasoning. On the stock shelves it shrinks somewhat, and also acquires varying degrees of hardness. Extents of both changes vary with different lots of material from the mixing machines, and even differ in the same batch.

Formerly it was the practice for the fabricating room supervisor to find by trial and error exactly how to "work" any lot. Now a micrometer is used having a pointed spindle and a tiny spring scale on the anvil. The spindle is advanced to the rod to be measured and the outside diameter found in the regular way. Then the foreman or machine set-up man who is using the instrument advances the spindle so that its point penetrates the stock, at the same time watching until the scale pointer comes to a predetermined mark. The penetration of the point into the material is a measure of the hardness of the stock and a guide to the setting of the tools for most rapid and successful machining.

X Marks the Spot

An Advance Account of the New Hillier Electron Microanalyzer Now Undergoing Development at the RCA Laboratories. Related to the Electron Microscope, It Serves a Different End, the Elemental Analysis of Minute Samples of Matter. Will it be Applicable to Industrial Laboratory Investigations?

By ALBERT G. INGALLS

RECENTLY, in a short communication to *Physical Review,* journal of American professional physicists, Dr. James Hillier of RCA Laboratories announced the preliminary development of a new fundamental tool to which he gave the name electron microanalyzer. Its function, he said, was the elemental analysis of extremely small areas within electron microscope specimens.

While the familiar chemical analysis can deal with specimens or samples that are small or even almost microscopic, and the spectrograph can give elemental analysis of still smaller specimens, the new Hillier instrument will go much further: With it the user can select from a specimen already so microscopic that it must be magnified thousands of times in order that its details may be seen at all, one local area or perhaps a particle no larger than 1/100,000 inch in diameter and as small in weight as 1/1,000,000,000,000,000 gram, and determine exactly which chemical elements that one single sub-microscopic area or particle contains. An instrument which can accomplish so remarkable a feat must be highly specialized and, in fact, superspecialized.

Just what this new tool will one day accomplish not even the wisest can now say, since there is no reliable way to predict the future of a baby. In the belief, however, that so specialized and powerful an instrument may prove ultimately to be one of the important working tools of science I went to the fine new RCA Laboratories, near Princeton, New Jersey, saw Dr. Hillier and used his electron microanalyzer.

Dr. Jim Hillier is not the "typical" scientist of fiction and the daily press; he looks and acts like an average human being. However, since the typical scientist of our day does look and act like an average human being, the "typical" scientist of ancient tradition being either imaginary or extinct, paradoxically Dr. Hillier is therefore a typical scientist. He is Canadian-born, now nearly U. S.-naturalized, and is 28 years old, a graduate of the University of Toronto where he specialized in mathematical physics.

If you look even a little into the technical literature of the electron microscope, of which Hillier's new electron microanalyzer is a relative, you find something like the following: German physicists developed the first crude electron microscopes about a dozen years ago; the first in the Western Hemisphere were built at the University of Toronto half a dozen years ago by Hillier and Prebus and were not crude; and Hillier came to RCA Laboratories four years ago and there, with A. W. Vance and under the direction of Dr. V. K. Zworykin, designed and developed a type of electron microscope that is adapted to practical industrial research. You also learn that more than 50 of these standard instruments are already in the laboratories, mainly of large industries and scientific institutions. Thus, Hillier is one of a rather small number of principals who have given science the electron microscope; also of a much smaller number who have made a practical working model actually available to industry.

HOW IT WORKS—Dr. Hillier, with Dr. Zworykin and Hillier's new and partly developed electron microanalyzer, the only working model yet in existence, are shown in Figure 1. This instrument is at present far from its production stage—some distance, in fact, from the end of its laboratory stage of development. How it functions may be told, skipping less essential details, in four stages.

First, the electron microscope, which is a built-in accessory of the electron microanalyzer, shoots electrons through a given specimen, in the ordinary manner of an electron microscope, and the highly magnified image thus produced is spread out on a fluorescent screen and studied visually.

Next, when and if some small local area, perhaps a particle, in this highly magnified image arouses the curiosity or suspicion of the user, the whole image is adjusted sidewise and endwise by means of mechanical control mechanisms until that area or particle is brought precisely under fixed crosshairs on the viewing screen.

Third, with this local area now put literally on the spot, a rheostat knob is turned and this refocuses and concentrates all the electrons that previously gave the broad field of vision into a single, narrow probe. The electrons now pass through that one area and no other.

Finally, these electrons, after passing into the atoms of the different chemical elements in the tiny area of the specimen selected for analysis, emerge from these atoms at *different rates of speed*

Figure 1: Dr. James Hillier (left), electron microanalyzer, Dr. V. K. Zworykin

for each element and are made to leave a visual record of these speeds on a photographic plate. This record permits identification of the elements in the area.

Figure 3 shows how these four steps are performed, and this calls for a short review of the electron microscope itself, described in Scientific American, July 1940, from which Figure 2 is reproduced. The two drawings show the close analogy of an electron microscope with the ordinary optical or light microscope.

In the light microscope the waves coming from a light-source are made plane by a lens L_1; the object to be examined is placed at *AB;* the lens L_2 bends the light that passes through it and forms a magnified image at *A'B'*. Then the next lens L_3 takes waves from a small piece of the image already magnified and bends them again, forming a once-more magnified image at *C'D'*.

INTERESTING DIFFERENCES—In the electron microscope almost the same thing happens, though under different auspices. Electrons which are accompanied or guided by waves as is now known, are shot off by the anode and fly away in streams of billions at velocities perhaps half that of light. Those that pass through the first magnetic lens L_1 are bent and made parallel. The object under examination is placed at *AB*. The second magnetic lens L_2 bends and magnifies, giving image *A'B'*, a small piece of which is again bent and magnified to *C'D'*. The analogy in basic working principle is almost complete but there are several interesting differences in method.

The first is that, while in the light microscope pieces of glass (lenses) shaped so that they will reduce the velocity of the light just the right amounts in the right places to accomplish their purpose are employed for bending the wave-fronts in order to form an image and bring about magnification, in the electron microscope the analogous bending is done by open-centered magnetic solenoid coils through which the electrons pass. Physicists also call these "lenses" because they accomplish the same purpose as lenses of glass, that is, bending or refraction; but the actual bending is of course done by the intangible magnetic field of force which they cause. Glass lenses would not suffice for the same purpose in the electron microscope because the glass would completely stop the electrons.

A second difference is that, while the waves used in the light microscope and received on the screen or retina within our eyes are perceived by this visual screen direct, the electron waves used by the electron microscope are far too short to be thus perceived, being only about 1/100,000 as long. They therefore have to be correspondingly lengthened. The zinc sulfide or other fluorescent substance on the fluorescent screen of the electron microscope has the power to take in short waves and lengthen them to visible length and send them out again. They come to this screen in such vast numbers and in such a fine pattern that they reproduce on the screen the original pattern of the otherwise invisible electron waves. That, then, is how we see with electrons —indirectly.

A third difference is that, while waves of visible light quite easily pass through the solid glass lenses and the air between them, the large air molecules, if permitted to remain in the electron microscope, would block the electrons

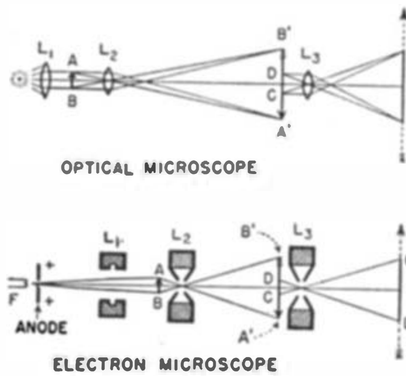


Figure 2: The analogy of two kinds of microscopes. Described in text

as easily as a bank of big boulders would block a swarm of small bullets. Hence, about 9,999,999/10,000,000 of these air molecules must be pushed and bumped out of the interior of the electron microscope by means of mechanical and diffusion pumps, and kept out, before that instrument can function.

A fourth difference is that, while the glass slides used for mounting specimens for the light microscope do not appreciably cut off the light, nor does the specimen itself in many instances, in the electron microscope the glass slide would stop all the electrons and so would the specimen unless it were very thin. Therefore, the specimen is mounted on a film of collodion only about 1/2,000,000 inch thick. The technique of mounting is, however, simple and requires but a few minutes. If the specimen itself is thicker than a minimum the electrons must be shot at it with greater speed in order to penetrate it.

A fifth difference—one that favors the electron microscope—is the flexibility of its lenses. Simply by turning rheostat knobs the magnetic fields in the magnetic lenses may be varied in strength by infinitely adjustable degrees. Only a "glass lens of rubber" could permit this amount of flexibility. However, because the magnetic lenses of the electron microscope seem so flexible and are intangible, there often is a temptation to assume that the standards of refinement of design and construction in one may be equally flexible and vague. This is far from true, since any but high tolerances in the mechanical construction of the critical components would ruin the functioning of the instrument. Similarly, the electron velocity and focal lengths of the magnetic lenses must be maintained uniform within one part in 20,000, else the instrument will not stay in focus.

So much for the electron microscope itself.

THE INITIAL SEARCH—Even a brief comparison between the electron microscope diagrammed in Figure 2 and the electron microanalyzer diagrammed in Figure 3 reveals that the Hillier electron microanalyzer includes an electron microscope. The same three magnetic lenses appear in each instrument. The envelopes of the spreading beams of electrons, as in Figure 2, are shown by short, incompleted but similarly spreading lines in Figure 3. This is the form they take when the user is examining the specimen in the initial search for some detail or particle in it to analyze. Through the magnifying eyepiece he sees the image on the fluorescent screen shown at the top in Figure 1.

Suppose that you are yourself the user of this electron microanalyzer and are doing medical research on the germ of a disease. For years you have been familiar with its rod-shaped bacilli as you frequently examined them with the light microscope at 1000 diameters' magnification or by photomicrography under the ultra-violet microscope's top-working, practicable magnification of 3000. In that kind of bacillus you were always able to make out, or resolve, some details — just enough to tantalize. Yet you knew that if you could see and study the full, actual details you might come to understand more about the functioning of that bacillus and perhaps, through that, find a new approach for attack on the disease it causes. Now the electron microscope becomes available and your enterprising organization obtains one. At one jump your top magnification rises from 1000 to 3000 diameters to 100,000 diameters and, since the observation of disease germs has been your lifelong career, you naturally become a bit excited and stirred by what you see. You discover that your bacillus assuredly has a considerable variety of details, as you had suspected, and is not just a lump. The whiplike appendages you had seen faintly with the light microscope are now found to have a much greater length than you or anybody had known. They also are more numerous.

Inside the transparent body of this little bacillus, itself only 1/10,000 inch long, you notice interesting granules, very tiny, which you did not even know existed, and as you gaze at them you mutter, "Never saw those before. Wonder if they aren't possibly the protein, concentrated in one place in this granular form." The electron microscope in itself cannot answer that question. Even with it you cannot analyze a granule merely by looking at it. You could, of course, perform a number of chemical tests on the bacillus until you found a reaction that would give you some knowledge of the chemical structure of the granule, but you would have to do this by looking at the granule in the electron microscope, taking it out and treating it with a test chemical, returning it, finding the same granule and checking to see whether there now was any difference. This would be very tedious and not too often successful.

AND IT ALONE—So with the electron microscope you can look at this granule in one end of one bacillus, but with the electron microanalyzer you also can analyze it! It and not the remainder of the germ. It alone. And in this fashion:

You manipulate the specimen until the bacillus and then its granule is in exact position under the cross-hairs. Then, with the rheostat knobs that alter the strength of the magnetic field you re-focus the instrument drastically. The formerly diverging lines of electrons that gave a broad-field view are made to converge. At the same time the image of the granule itself grows in size. It expands about its own central point and eventually it—the image of that one single granule alone—covers the whole fluorescent screen. Now the electrons are moving in the paths enveloped by the full-length lines of Figure 3. The tip of the electron needle, so extraordinarily fine that it is no bigger at the point than the particle to be analyzed, is just touching the granule in the specimen (which, by the way, in the "silhouette," or "shadow," type of instrument used in the electron microanalyzer is placed two stages nearer the top than in the standard type). Now the electrons are all passing through that granule and no other part of the general specimen or even of the bacillus. Their velocity has been stabilized so that they all have exactly the same speed.

Next, the velocity analyzer is switched on. This consists of a large electro-magnet, its oblong coil showing in Figure 1 just in front of Dr. Hillier's left hand. This magnet applies a homogeneous magnetic field to the gap through which the electrons travel, and this uniform magnetic field deflects each speeding electron in proportion to its velocity. Thus, the slowest electrons are able to make the shortest U-turns, faster ones make larger U-turns, while the speediest go farthest out and around.

After traversing its U-turn, each electron in this "half-circle type of velocity analyzer," as physicists term this particular type of apparatus, strikes a photographic plate and wherever this is struck it is exposed. When the plate is developed it is seen to bear markings, of which those sketched under it in Figure 3 are characteristic. In this sketch of an "electron velocity distribution" the hits are seen to be bunched or concentrated at certain distances from the edge of the plate. Actually, because there is some unavoidable electron scattering, the electrons fall to some extent all over the plate, but a smooth curve of their frequency, of which the one also sketched in on Figure 3 is typical, reveals that most of them strike at or near certain significant distances measured from the edge of the plate. *Each distance corresponds to a different chemical element.* And there is your analysis.

In another instance you have in your hand a test tube in which are a number of mixed chemicals. Suppose you have put a tiny sample of this mixture in the electron microscope and examined it. Yes, there are some particles, several types of them, and these types undoubtedly make up some of the chemicals that were in the test tube but which are which? This you cannot tell. Merely by looking at them you cannot distinguish which particle is one chemical and which is another. This, on the other hand, is one of the kind of things the electron microanalyzer should be able to tell you direct and quickly.

Just exactly why the electrons, after passing into atoms of different chemical elements at uniform speed, emerge at different speeds, is a question you may have been asking. It has been explained thus: "On the basis of the physical knowledge already in existence, we can visualize the atoms of the target as being heavy nuclei surrounded by a number of electrons. These electrons arrange themselves into what are often called shells. As we go through the table of chemical elements we find that the most noticeable difference from one element to the next in

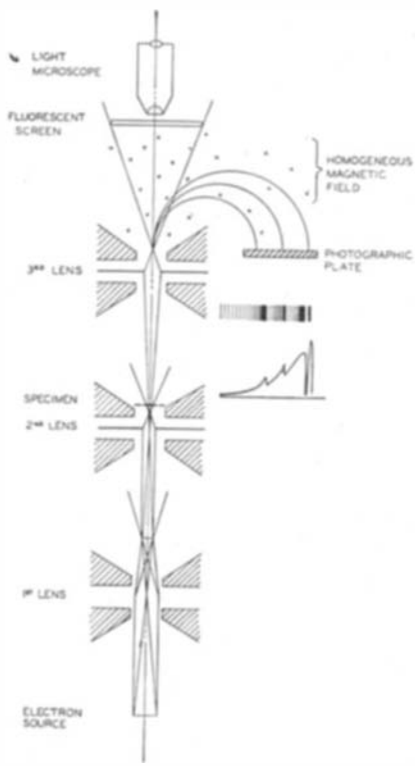


Figure 3: An elevation diagram of the electron microanalyzer. See text

the structure of the corresponding atom is the addition of an electron to the outside shell, the addition of a unit of positive charge to the nucleus, and the addition of more mass to the nucleus. Thus, the innermost part of the atoms of different elements is very similar, consisting of the nucleus, two electrons swinging around what is known as the K-shell, eight slightly farther away in the L-shell, and so on, until in the heaviest atom you have 92 electrons all told. It takes a certain amount of energy to knock an electron out of an atom and the closer that electron is to the nucleus—the nearer to the K-shell—the more energy it takes, and the energy is taken from the original incident electron. In other words, as a result of the collision, the fast-traveling electron will continue on its way but will have been slowed up a little. This is what leads directly to the experimental arrangement in the electron microanalyzer. If the specimen is thin enough and the electrons are going fast enough they will not collide with more than one or two atoms in it." For greater penetration electron microscopes employing higher voltages to speed the electrons faster may be used. RCA has one working at 300,000 volts.

Thus far, Dr. Hillier has calibrated his electron microanalyzer for only a part of the elements—those most important in biology, such as carbon, hydrogen, oxygen, nitrogen, calcium, and potassium. Work on the others proceeds. He has not yet reduced the instrument to a basis of quantitative analysis—it is still qualitative in nature—but that may follow. It is not, however, anticipated that it will ever be able to do the analyses of chemical compounds. That is, it might tell us that a given particle contained, for example, hydrogen, carbon, oxygen, and nitrogen, and perhaps later how much of each; but it can scarcely be hoped that it can even tell us how these atoms are combined into chemical compounds. There are, however, many circumstances under which experienced chemists can make shrewd and helpful guesses.

INDUSTRIAL POSSIBILITIES—Could not this instrument, when fully developed, find many practical applications other than the biological, with which its initial experimental trials have been made? May it not, with its special "micro-micro" power of analyzing single submicroscopic particles, prove to have even greater uses in the laboratories of the industries, possibly for the precise study of microscopic impurities in commercial products?

The development of the electron microscope belongs to a number of scientific men but the electron microanalyzer is Hillier's. He brilliantly combined several parts and principles previously known to physicists (some of which he also further developed) with the use of the electron probe to increase the precision of the electron velocity analyzer. In fact, it is the double use of the electron probe in one instrument that makes the electron microanalyzer the highly specialized instrument that it is. In other words, no probe, no microanalyzer.

In answer to direct questions Hillier says the whole idea, with the several organized essential parts and principles, working together to one end, popped into his head one day without conscious cerebration. Inventors speak of this type of discovery as "flash of genius." This is sometimes mistaken to mean that no real work has been done and that, simply, an angel flew down, handed the favored recipient a finished blueprint, smiled, and flew away. Actually, it usually means, as it did in this instance, that much conscious cerebration has previously been done in and around the subject, and for most of us cerebration is work, a form of suffering. Even when the "angel" has imparted the bright idea the sufferer's troubles have only just begun; for he isn't yet half-way to first base. With the still infant electron microanalyzer Hillier is now leaving third base for his home run. I found him at work on it in his laboratory in his shirtsleeves.

Jet-Propulsion Flight

The New Jet-Propelled Plane Flies Fast and is Safe. An Analysis Reveals its Superiorities and Inferiorities and Points Out its Possible Future. The Struggle of its Oft-Frustrated Inventor and His Final Success Affords a Romantic Story of a Young Man's Determination

LAST month's article reviewed the aviation engine of today, thoroughly modern, constantly improving and growing in power and efficiency, but still of conventional design and well-tried principles. Now the dramatic announcement of the Bell Interceptor fighter, powered with an engine of the so-called rocket type, makes it timely to discuss this radically new power plant.

Since press and public alike speak indiscriminately of rocket and jet-propulsion engines, a definition or two may be helpful.

In both types the propeller has gone. In both, combustion or detonation is made to occur in a chamber and the gases, which are the products of the combustion, make their exit toward the rear through orifice or nozzle, at high temperatures and high speeds.

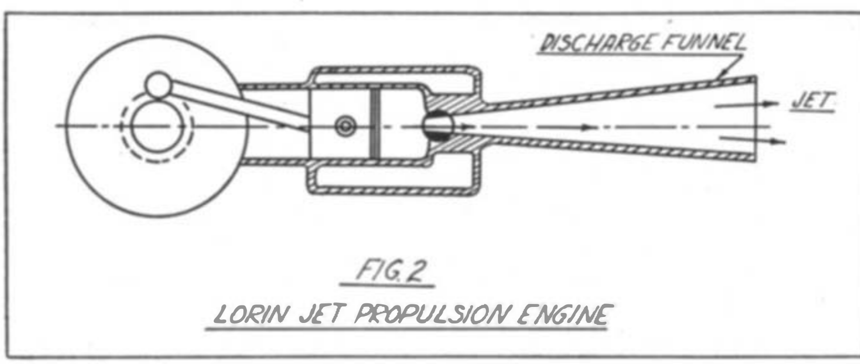
NEWTON'S LAW—Pressure inside the chamber drives the gases out. On Newton's law, that action and reaction are equal and opposite, a thrust is exercised on the combustion chamber or engine, and hence on the airplane or other vehicle (Figure 1).

While the above description applies equally well to rocket and jet-reaction engines, in the rocket a mixture of fuels contains within itself the oxygen necessary for combustion; in the jet-reaction engine, the fuel is carried in the vehicle but oxygen is fed by air from the outer atmosphere.

Important as the rocket may be in the exploration of the upper atmosphere or ultimately as a method of interplanetary travel, in aviation the jet-reaction engine is the greatest concern.

The new Bell plane, equipped with two jet engines, flies between 500 and 600 miles an hour (nearly 100 miles an hour faster than any other type of aircraft). The engine has been built by General Electric, the plane by Bell Aircraft Corporation. Instead of expensive, highly volatile, high octane gasoline, the engine can employ kerosene or almost any variety of liquid fuel. The chief immediate application of the engine will be in interceptor fighters or high-altitude reconnaissance aircraft—the fuel consumption per horsepower hour is far too great for the engine to be used in bombers or any craft, for that matter, in which sustained operation may be required. It might conceivably be installed in existing heavy bombers, however, to obtain "flash performance," to help big planes to get off with heavier loads or to give them a burst of speed in getting away from attackers.

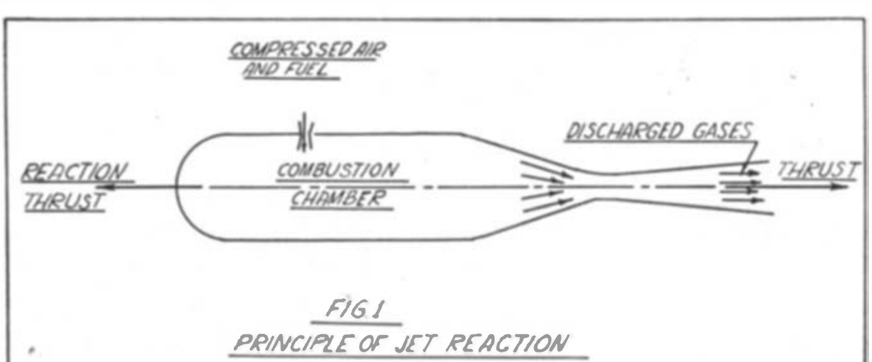
According to Brigadier General B. W. Chidlaw, Chief of the Materiel Division of the Army Air Forces, our pilots will find no trouble in operating the new aircraft. There are, according to General Chidlaw, two distinct sensations in flying the jet propelled aircraft—lack of noise and lack of vibration. The plane is neither noiseless nor does it fly with the speed of sound, but the elimination of the propellers and the fact that the noise from propulsion is to the rear makes for quietness in the cockpit and reduces pilot fatigue.



An impractical scheme

The absence of vibration should have several advantages, including ease of handling, particularly in fight maneuvers, and in reducing wear on structure and instruments. To those below, the new plane in flight sounds like a tremendous tea kettle at full boil; persons in an English district where its experimental flights have been made, have nicknamed it the "squirt." It is an awe-inspiring sight to see the aircraft become visible on the horizon, pass in view for a few seconds, and vanish specklike on the opposite horizon. That the new planes are likely to be safe in piloting as well as highly effective is attested by the fact that several hundred successful flights have been carried out by American pilots in the United States and British pilots in England without a single mishap.

The development of the jet-propulsion engine illustrates once more the wonderful co-operation which exists between the American A.A.F. and the



Illustrations redrawn from "Flight"

How thrust is exercised

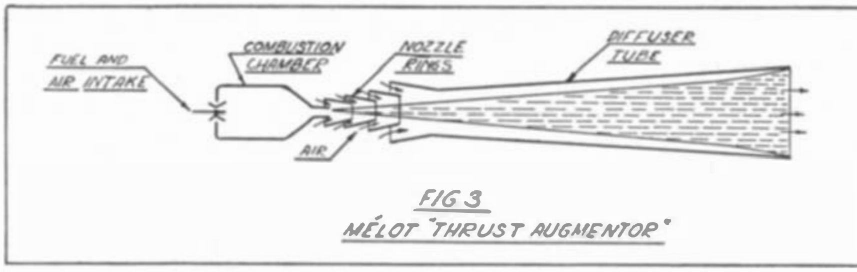
British R.A.F. The British Air Ministry placed its first order for an aircraft using a jet-propulsion engine in 1939 with the Gloucester Aircraft Company, and engines and aircraft were ready May 1941, but the United States was fully informed well before our entry in the war, namely in July 1941. Ever since then the A.A.F. and the British Ministry of Aircraft Production have been in constant co-operation and have exchanged all information obtained.

There are two types of efficiency to be considered in an aircraft engine—thermodynamic or internal efficiency, and propulsive or external efficiency.

The thermodynamic or internal efficiency of an internal-combustion engine—the ratio of the power developed to the thermal energy contained in the fuel—is quite low. The number and character of the losses is ominous. Thus there are chemical losses owing to incomplete combustion, bad mixing of gases, loss of fuel through exhaust. Then there are cooling losses through the walls, losses through pistons and valves and in inlet system and carburetion. Mechanical losses amount to 15 percent, exhaust losses to 30 percent, and the overall internal efficiency amounts to only 30 percent or thereabouts.

COMPLETE COMBUSTION—In the jet-propulsion engine, the picture is quite different. Combustion can be complete and, since there is no piston to seize up, there is no necessity for cooling losses and chambers could even be lined with refractory materials. The chemical losses are eliminated and, with a long exit nozzle, it is possible to go a long way toward converting heat energy into kinetic energy, so that exhaust losses are reduced to a minimum. Some well-informed German writers have estimated internal efficiency to be as high as 70 percent, and Professor Goddard's experiments indicate internal efficiencies of the order of 50 percent.

But when external or propulsive efficiency is considered, conditions are completely reversed. The modern airplane propeller is highly efficient and, in its best form, with controllable pitch, its efficiency may be as high as 85 percent. In the jet-reaction engine the propulsive efficiency is very low. The gases leave the combustion chamber at high velocity, say 6000 feet per second, and produce a thrust, *T*, by reaction. Suppose the airplane is itself moving at 600 feet per second. Then the work done on the airplane is (*T* x 600); the work done on the gases is (*T* x 6000). The efficiency is the one divided by the other—only 10 percent.



A distinct advance in jet reaction

In this only approximately correct exposition can be seen the main difficulty of the jet-reaction principle. The gases come out too fast and carry away too great a proportion of the energy of combustion.

What are the possible remedies? First, very great speeds of the airplane itself, which means flight at high altitudes; second, some way must be found of mixing great quantities of air with the jet. The mixture of burned gases and air would then leave the jet-reaction engine at very much lower speeds and the external efficiency would be very much greater.

Examining the history of the art it will be found that many different proposals and inventions have been made, dating back many years. In fact, there have been so many of these proposals that anything like a comprehensive review is impossible in this article. One of the best sources of information is a series of brilliant articles by G. Geoffrey Smith in *Flight* (London). While we do not always share Mr. Smith's views, we have found his splendid summary of the early art tremendously helpful.

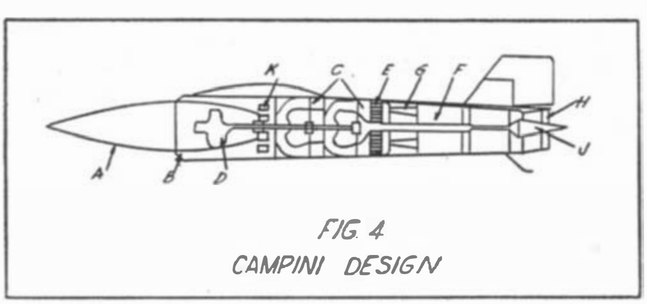
Perhaps the simplest illustration of a jet-propulsion engine is that shown in Figure 2, a scheme devised by the French engineer Lorin. Monsieur Lorin imagined that he could take a simple internal combustion engine of the reciprocating type, charge, compress, expand, and exhaust the gases in the usual fashion but, instead of the engine driving the propeller, the gases were to be made to pass through a reaction jet. While this simple scheme illustrates principles in a graphic manner, it cannot be considered at all practical. Monsieur Lorin's scheme combines all the difficulties and losses of an internal-combustion engine with the propulsive or external inefficiency of the jet-reaction engine.

FRENCH CONTRIBUTIONS—Lorin is but one of many French inventors in this field. The French have apparently the national characteristic of taking up new ideas in brilliant fashion ahead of anyone else but are not so likely to carry through to the end. They did, however, contribute wonderfully to the basics of jet-propulsion flight. Thus the Melot thrust augmentor, as illustrated in Figure 3, was a distinct advance. The principle is that, as the gases leave the combustion chamber in a rearward direction, additional air is sucked through a series of nozzles of increasing diameter into a diffuser tube. As a result, the thrust is augmented by an additional mass of air. This device, subsequently tested by engineers of the National Advisory Committee for Aeronautics, did indeed increase the thrust, perhaps as much as 37 percent over the theoretical thrust of the free jet. Of course, this is still far from removing the propulsive inefficiency of jet reaction but it does show that augmentation is a useful idea.

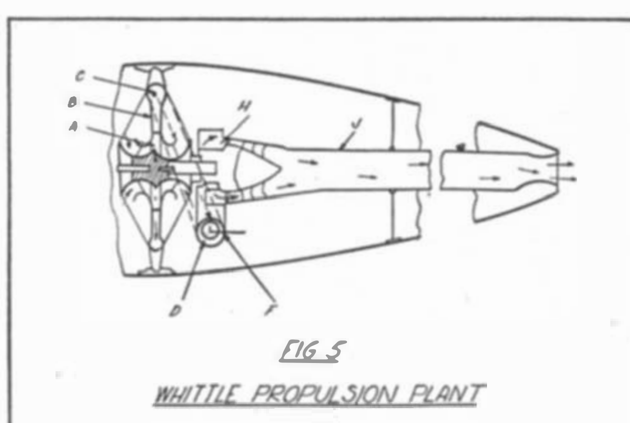
Other devices have been proposed by the Junkers Corporation of Germany, by Dr. Eichelberg of Zürich, Switzerland, and by a number of British workers besides Captain Whittle.

As far as is known, the only jet-propelled plane which has actually flown prior to the Whittle design is the Caproni-Campini machine, which, on November 30, 1941, made a flight from Milan to Rome at an average speed of 130 miles an hour, which is low for a machine of this type.

A purely diagrammatic representation of the Campini design is shown in Figure 4. Air is admitted between the cabin *A* and the enshrouding cylinder. A radial internal-combustion engine drives a two-stage centrifugal compressor *C*. Beyond the compressor, the air



The first jet-propelled plane to be flown used a power plant of this type. Parts are explained in the text



Right: Basic elements of the Whittle conception of a simple jet engine, incorporating an effective gas turbine

passes through a radiator, which also acts as a rectifier, into a large combustion chamber *F*. An annular mixing channel *G* supplies vaporized fuel into the combustion chamber. After combustion and expansion, the gases discharge at the rear through a discharge nozzle *H*. The nozzle orifice can be varied by cone *J*.

The Campini design was not very efficient but it did comprise the essential elements and principles of the jet-reaction engine and plane, such as a combustion chamber to which fuel is suitably applied and a compressor so that a far greater weight of air passes out through the rear nozzle than the weight of fuel actually burned. But it certainly adds to complexity to have a reciprocating internal-combustion engine, and the thermal efficiency of an internal-combstion engine is none too high. The Campini power plant is both heavy and complicated and takes up the entire space of the fuselage, which is a drawback. Moreover, no attempt was made to recuperate energy from the internal-combustion engine exhaust.

Captain Whittle has advanced a number of plans for his jet engines. Figure 5 shows the basic elements of one of his conceptions: *A* is a compressor impeller; *B* is a primary diffuser chamber; *C* is an air delivery scroll. The compressed air is delivered to the helical combustion chamber, *D*, where it is combined with fuel by fuel injector, *F*. The products of combustion then drive the turbine rotor, *H*. The turbine itself drives

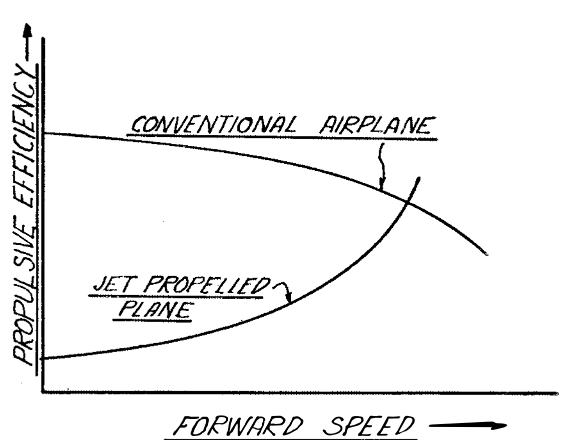


FIG. 6

Efficiency curves for two types of aircraft propulsion

YOUNG MEN AT WORK—Inventions are almost certain to be opposed in their earlier stages by "official" scientists. They will be adopted by governments only after determined and lengthy effort. They are almost certain to come from young men. The opposition comes because it is always easier and safer to oppose. Young men are likely to be the inventors because they have greater imagination and greater optimism, and are less harassed by duties and affairs. The story of Group Captain Frank Whittle, inventor of the first succesful jet-propulsion engine, bears out these views. Dr. Edgar Buckingham, of the Bureau of Standards, as the result of an early study for the National Advisory Committee for Aeronautics, gave as his opinion that "the fundamental disadvantage of high jet speed and poor ratio of conversion of heat into thrust work would remain an insuperable obstacle to the use of such jets." In Captain Whittle's case it was not the Government that provided the classic opposition to a new idea, but industrialist after industrialist turned down the invention and the Captain was about to give up in despair. For five years he did nothing about the original patent taken out in 1930.

Frank Whittle is only 36 years old now, and it was while studying at Cambridge University that he explained his ideas to four of his friends—Johnson, Wing Commander G. Lees, J. C. B. Tinling, and R. D. Williams. Messrs. Tinling and Williams, former R.A.F. men who had a small business together, managed to raise some money and it was the enthusiasm of a group of young and air-minded men which was the greatest factor in carrying the venture to success.

the compressor impeller, and the products of combustion, after passing through the turbine, are drawn rearward to provide jet reaction.

In basic principle there was little difference between Whittle and Campini. The Whittle design has the advantage that a very simple and effective gas turbine is substituted for an internal-combustion engine. The simplicity of the design is marked. Captain Whittle has advanced other plans, but military secrecy does not permit description of the exact plans employed.

In principle, the jet propulsion of aircraft has been solved. How soon and under what conditions will it become a serious competitor with the conventional reciprocating engines and screw propeller? Up to limited altitudes, the conventional aircraft power plant provided with a suitable supercharger remains surprisingly efficient. Even at as great altitudes as 40,000 feet and with the aid of gear-driven or turbine-driven superchargers, the power of the engine may be substantially maintained and the efficiency of the propeller can remain very high. But at very great altitudes, the air becomes so thin that it is exceedingly difficult to maintain the power of the engine. The supercharger itself now absorbs so much power that the net output of the engine is seriously diminished. At the same time, owing to the low density of the atmosphere at great altitudes, the propeller, in spite of variable or controllable pitch, becomes increasingly incapable of absorbing the engine power and also loses in efficiency. Thus the efficiency of the conventional aircraft power plant, stationary up to a certain altitude, thereafter begins to drop off rather rapidly.

On the other hand, the jet power plant is very inefficient at sea level at relatively low speeds. At very high speeds and in thin air, the expansion through the nozzle is facilitated and the internal or thermal efficiency of the engine remains stationary or drops off but little. Further, since at great altitudes the speed of the airplane increases, the external propulsive efficiency of the jet engine increases to a marked degree.

FUTURE OF THE JET—The dropping off in efficiency of the conventional power plant and the increase in efficiency of the new power plant is diagrammatically illustrated in Figure 6. Perhaps a point has been reached where the two curves cross, but if not, it will be reached very quickly, and at that time the jet engine will come into its own.

An aspect of the jet-reaction engine which may be applied on a wide scale quite shortly is in the problem of assisted take-off. As heavy bombers and trans-oceanic aircraft fly greater and greater distances, they burn more and more fuel, and as a result the bomb-load or pay-load falls off appreciably. If a jet or rocket engine is employed for just a few seconds, or half a minute at the most, it is possible to make a take-off with a far greater gross weight. The larger gross weight, in turn, has a very marked effect on bomb- or pay-load. For trans-oceanic travel of the future, it is quite possible that some form of assisted take-off will become absolutely indispensable. Also if long-distance raids are going to be made on Japan, is it not conceivable that jet or rocket engines shall be used?

Other aspects of jet reaction are equally interesting. If the exhaust system of the conventional aircraft power plant is suitably designed so that the gases expand, emerge at high speeds and give additional thrust, it is already possible to recover from the exhaust in our ordinary aircraft between 5 and 10 percent of the brake horsepower of the engine. Surely that should not be neglected. Strange as it may seem, radiators may also be made to deliver thrust. If a cooling radiator is placed in the wing, the air, when passing through the radiator, absorbs energy and heats up. Therefore, when it is led to the trailing edge of the wing the speed of the air is increased. As a result, instead of the radiator producing resistance, it actually produces, by reaction, a rearward thrust. While neither the thrust reaction of the exhaust system nor the thrust of the radiator are any too high, they all help and the utilization of jet reaction and its thrust is being approached from many directions.

Even though the fuel consumption at the present moment with jet-propulsion is probably between two and three pounds a horsepower-hour, so that jet

(Please turn to page 192)

'Our Business Is - - Improving'

Research Facilities are Made Available for Small Businesses Through the Activities of the Armour Foundation. Without Huge Investments, Industries that Cannot Otherwise Afford Research Laboraories are Placed on the Same Basis as Big Business

By FRANCIS SILL WICKWARE

SOME TIME AGO, an executive of a fountain-pen company took a plane trip. He forgot to empty a brace of pens in his vest pocket before going aloft; when he landed, his vest, shirt, and undershirt were soaked with ink. This executive had written many advertisements which described his pen as "the ideal fountain pen." Obviously, the pen wasn't ideal if it leaked in an airplane. What, he asked himself, could be done about it?

Apparently nothing could be done. All fountain pens were constructed on the same time-honored principle. At high altitudes, lowered atmospheric pressure allowed the ink to leak. No manufacturer had succeeded in preventing this.

Ink might still be oozing out of pens in planes, if the executive hadn't happened to hear of the Armour Research Foundation, an engineering and research institution affiliated with Illinois Institute of Technology. "We can make almost anything. We can improve anything. Within reason, we can invent anything." So states unorthodox Mr. Harold Vagtborg, 38-year-old Director of Armour Foundation. In the case of the leaking fountain pen, which was accepted as a research project, Vagtborg and his colleagues characteristically attacked the problem by forgetting everything they had ever been told about pens. "What is this thing? What's it for? How does it work?" they asked.

Starting from the ground up, they first made a thorough study of the basic principles of fountain pens, then constructed a totally different pen which could be carried to the moon and back without losing a drop of ink. The solution — so simple that no one else had thought of it — was a pen with two reservoirs, one connected with the other. At low altitudes, ink stayed in the main reservoir, as in conventional pens. At high altitudes, under reduced pressure, the pen leaked — but only into the *second* reservoir, which served to equalize external and internal pressures at all altitudes. This improvement alone (and there were several others) led to such an increase in sales of the pen that the $7500 research cost was more than met in a few months.

Another example of the Armour Foundation's open-minded approach to industrial research was the Elgin Watch project. About three years ago, T. A. Potter, president of the Elgin company, arrived at the unprepossessing Armour administration building, a converted red-brick apartment building on Chicago's South Side. Potter brought with him an especially troublesome problem. Manufacture of certain watch parts, so small that 300 of them could be placed in a tiny thimble, was slow, difficult, and costly. At one stage in the process these small pieces were heat-treated; and too often during this heat treatment whole batches fused and were useless. The result was that only one third of the total pieces produced were of the quality demanded for Elgin watches. Not even the master watchmakers of Switzerland knew how to overcome this difficulty.

NO RESULTS, AT FIRST — Armour undertook the project and gave itself 12 months to find the answer. From the start it was obvious that the solution hinged on developing a new method of heat-treating the watch parts. Much work already had been done in this field, and all authorities and textbooks agreed on certain standard methods; but none of these methods worked to complete satisfaction.

For 11 months Armour Foundation men worked along conventional lines — and got nowhere. Then Dr. C. N. Challacombe, staff physicist, decided to throw away the textbooks and forget the authorities. Thirty days later he walked into Potter's office at Elgin, Illinois, and dropped a handful of the little watch parts on the desk. They were bright, new, perfect, and they didn't stick together. Once having freed his mind from the orthodox verdict that it couldn't be done, Challacombe had speedily invented an entirely new heat-treating method which depended upon more perfect furnace atmosphere control and which produced nearly perfect batches of parts.

In seven years Armour Foundation has grown from a name and a good idea into one of the most important institutions of its kind in the United States. The "good idea" was to provide an industrial research service for the particular benefit of small business. Of the 100,000 industrial and manufacturing companies in the United States, only 2000 have any research facilities of their own. A few giants like General Motors, Westinghouse, DuPont, Bell Telephone, General Electric, and Standard Oil have invested millions in their laboratories, but little business has no such sums to spend. To equip a modern laboratory would bankrupt most such companies.

The Armour Foundation will undertake a project in practically *any* field; nothing is too large or small, too simple or complex for investigation. It does a lot of work in long-range problems, but is also always ready to undertake short-term investigations for small companies which have day-to-day problems.

Checking noise on a new comptometer model, made quieter through research

In working out solutions to the problems presented, the Foundation pools the brains and experience of its staff of more than 200 technicians and research experts. Many minds thus are constantly working on a great variety of projects. A chemist consulted on an engineering matter may have just the right slant that will lead to a solution. Conversely, an engineer may solve a problem in chemistry. It is *group* science, *group* research, that gets results.

Armour is not endowed; it depends solely upon the income derived from "service fees." These fees range from $5 (for a minor problem) to $100,000 for several years of work on a long-range project. The average Foundation project costs the sponsor $8500 a year. Clients frequently are so pleased with the results that they contribute money or equipment. A foundry equipment company gave $30,000 cash for the Foundation's "general welfare"; a steel company contributed a $20,000 induction furnace. Other donations include a multiple-stage hydraulic press, a testing machine which can crush concrete pillars, a Bessemer steel converter with electronic control, a spectrophotometer, and many other complicated scientific gadgets. All told, equipment worth $500,000 has been contributed.

MINIATURE INDUSTRIAL PLANTS — Due to the practical nature of the research, many of the Armour laboratories are miniature industrial plants. There is, for example, a complete, working flour mill, a candy factory, a rotary kiln for cement production, a midget steel rolling mill, an iron foundry, and a complete line of electrical equipment. Other facilities include a biochemical lab, a plastics lab, a shock test machine that develops impacts of 2000 foot-pounds, and a huge smelter where Armour metallurgists melt steel with ultra short-wave radio. There are elaborate photographic laboratories, with photo-electric, photomicrograph, stereocamera, and stroboscope apparatus, used mainly in stress analysis and in detailed studies of machinery operation. There is also a thermal chamber where artificial weather is manufactured to order. Here Armour tested strathosphere equipment for the Army, at a temperature of 67 degrees below zero, and with an artificial 200 m.p.h. wind blowing. Another time, the exact climatic conditions of the South Pacific were reproduced in midwinter for tests of drums and containers used for storing aviation gasoline.

Since Armour is willing to tackle practically anything, its projects cover the whole range of technology. At one end of the scale is the pioneering research into the behavior of lubricants under the terrific hydraulic pressure of 1,500,000 pounds to the square inch. At the other end of the scale was the problem of the candied cordial cherries, sold by newsboys on a western railroad. On certain trains — but not on others — juice leaked out of these candies. One of the Armour researchers placed a box of the cherries in the Foundation's altitude chamber, and, sure enough, when the needle registered a pressure equivalent to 6000 feet altitude the cherries leaked. Like the fountain pens, they couldn't stand high altitudes. Armour's suggested solution: A reinforcing chocolate shell for the cherries. For this service the Foundation charged its client $15.

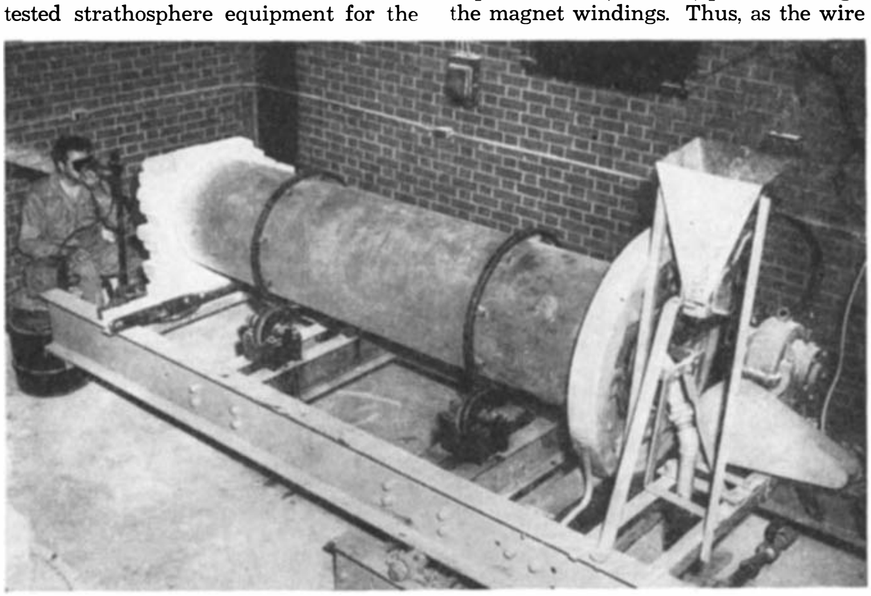
One of the most interesting things to come out of the Armour Foundation so far is a new sound recording device called the wire recorder. This was developed, not for a sponsor, or in the course of a project, but independently by an Armour staff physicist, 26-year-old Marvin Camras. Camras' cousin is a singer, and he wanted to make some recordings of his voice for study. Wasn't there a better way of recording sound than with the conventional, unwieldly disk-cutting equipment?

From his studies of electricity and magnetism, Camras knew that, back in 1898, a Danish scientist named Valdemar Poulsen had shown that it was possible to record sound with a series of magnetic "impressions" on metal. But Poulsen had never been able to lick all of the problems involved and finally abandoned his experiments.

With this background Camras set up an arrangement of magnets between which passed a moving steel wire. Sound waves were transformed into electrical impulses which, in turn, passed through the magnet windings. Thus, as the wire moved between the poles of the magnets, it received a series of magnetic impressions which corresponded to the original sound vibrations. Then, when the magnets were connected through amplifiers to a loudspeaker, and the wire was repassed between the magnetic poles, the sound was reproduced.

High pressure investigation set-up

Camras noticed that as his wire slowly travelled between the magnetic poles it twisted and turned, distorting the sound. He didn't realize it then, but this was what had been wrong with those earlier experiments. Camras remedied this defect by bringing the magnetic poles very closely together and providing a tiny hole or groove for the wire. This one small improvement created a new recording instrument which can well make all existing phonographs and record-cutters obsolete. With the new wire recorder, eight hours of continuous sound can be recorded on a spool of fine wire five inches in diameter and ten inches deep.



Reading temperature in a pilot rotary kiln in the Armour Minerals Laboratory

VALUABLE NOW, AND POST-WAR — The wire recorder has so many military uses that it won't be available for civilians until after the war. In radio monitoring stations, for example, it takes down millions of words of foreign broadcasts. On the fighting fronts it is carried with advancing troops and records the sounds of an entire battle. In commercial planes, with microphone equipment, it serves as an automatic log of the flight, and—housed in asbestos—can survive a crash and recount the reasons for it. Now manufactured by General Electric under a non-exclusive license, with royalties shared jointly by Camras and the Armour Foundation, the recorder has proved so valuable that every completed unit is rushed to the services. Arrangements are currently being made with other manufacturers, each to produce the instrument for a specific field of application.

Peacetime uses of the recorder, which is not much bigger or heavier than a portable radio, will be tremendous. It will be possible to record everything from favorite bits of jazz to whole symphonies and operas, either by radio, or

in theaters, night clubs, and concert halls. It will be available to record speeches, meetings, conventions, court trials, sessions of Congress.

[Editor's Note: It should be noted here that one of the reasons why earlier experimenters in the field of magnetic recording were unsuccessful was the lack of adequate means of amplification, now available in the vacuum tube. Early reproduction was faint and too noisy to be useful. However, in the 1930's, Dr. C. N. Hickman of the Bell Telephone Laboratories took up the investigation in the light of modern techniques. He used a tape of very retentive magnetic material a thousandth of an inch thick and a few thousandths wide, rather than the wire employed by Poulsen. Thus were eliminated the troubles due to twisting of the recording medium. A number of commercial applications have been made of Dr. Hickman's development, notable among them being the weather-forecast service offered by several telephone companies; a recorder for incoming news dispatches used by two New York newspapers; and the Mirrophone, a portable device used for voice culture and study whereby one can immediately play back a recording of one's own voice.]

NOISE REDUCTION— Armour research already has affected millions of people through improvement of common articles and commodities in everyday use. Contributing to the comfort and efficiency of office workers was a project sponsored by the Felt and Tarrant Company, manufacturers of the Comptometer. The machines were noisy; the din of a battery of them distracted everyone within earshot, increased fatigue, and impaired the efficiency of an entire office. This had been proved by exhaustive studies. In 1938 R. J. Koch, head of Felt and Tarrant, turned over the noise-removal job to Armour. Under the direction of Dr. H. A. Leedy, Armour research eliminated 94 percent of Comptometer noise. As is often the case in such projects, it was possible to eliminate much vibration—and, hence, noise —merely through changes in shape and mass of certain parts. In addition, the use of special materials contributed further to the absorption of some vibrations that could not otherwise be eliminated.

Of great potential importance to home-owners and motorists is a new fuel—half oil and half coal—developed during a project to discover possible uses for coal dust, which always has been a nuisance and a waste around mines. The Foundation discovered that finely pulverized coal dust suspended in low-grade oil made an excellent heating fuel of great economy, and that with certain adjustments and changes in the fuel-handling system a stock-model automobile could be driven on it. The Foundation doesn't think that the new fuel will take the place of gasoline right away, but if the motor-fuel shortage becomes more critical it might be used as a substitute.

Failure sometimes is as gratifying to a client as success. Recently, the Foundation was forced to admit to an important client that after two years it had made absolutely no headway with a confidential problem he had brought in. At this the client smiled, rubbed his hands, and said: "Gentlemen, the project has been eminently successful. You've convinced me that I can't improve my product the way I wanted to, and you've also convinced me that my competitor can't improve it either."

One of the major activities of the Foundation is the National Registry of Rare Chemicals, outgrowth of a rush project undertaken early in 1942. The work required a quantity of a rare compound designated as "1, 1 dichloro 1 nitro ethane." None of the well known chemical companies or laboratories had any of the stuff, and it took Armour a month to find what it needed, thereby

Checking the frequency response of new magnetic wire sound recorder

endangering the whole project. This convinced the Armour staff of the need for a national clearing house for hard-to-find chemicals. The Armour Registry does not stock any chemicals, but keeps the names of some 6000 on file, with directions for producing them. So far it has received over 2500 requests—many from foreign countries—and has been able to answer 75 percent of them, usually within a couple of hours.

Today Armour Foundation is 100 percent devoted to war products. Many technological wonders lie hidden behind the veil of military secrecy, but Director Vagtborg is free to make some predictions about the future. One of these concerns "radio cookery," an outgrowth of diathermy and "artificial fever" treatment. He prophesies that we shall have electronic cooking as a generally accepted commercial practice, but doubts its use in the home because of the hazard of high voltage. One commercial company has already perfected a thermal radio hamburger and hot-dog vending machine. The customer drops a coin into a slot, and after half a minute a radio-cooked morsel pops out.

In choosing personnel, the Armour motto has been "Get the man who is arriving, not the man who has arrived." The result is a group of "boy geniuses" of science. The assistant director of the Foundation is 33 years old—slight, blond-mustached Dr. Francis Godwin, who looks like a college freshman, but who is already a world-famed chemical engineer. The heads of chemical engineering and engineering mechanics likewise are in their early 30's.

Once every summer Director Vagtborg takes his section heads and senior staff members off on a busman's holiday to the North Woods. There, cut off from communications with the outside world, they hold policy conferences and devote four hours a day to intensive study of problems. The rest of the time they fish. "The fishing is essential," Vagtborg comments. "It breaks down stratification and cliques, failings which are in the scientific tradition. It gets the men together again and helps their minds to mesh. In fact, it's an important part of the Armour Plan."

The essential, long-range purpose of the Armour organization is to give small business a chance to compete with big business on equal terms, as far as research is concerned. The Foundation has already served 1100 companies in this way.

* * *

TINY FLUORESCENT

Lamp Operates on Small Fraction of a Watt

No LARGER than a marble, a new fluorescent lamp has been developed that operates with remarkable efficiency. It gives off more light than a quarter-watt neon glow lamp that consumes two and a half times as much power, according to Westinghouse engineers. For the first time, modern fluorescent lamp efficiency has been obtained in a miniature-size light source. Thirty of these tiny bulbs take no more energy than an electric clock. This economy adapts the new lamp to many military applications where very little energy is available. Using energy from dry batteries, it might be used to mark a cache of supplies to be left unattended for months. It could also be used as a flashing lamp on life rafts. If available after the war for household use, the lamp could burn constantly for six months (to mark a stairstep or keyhole) for about a cent's worth of electricity.

HYDROPONICS

Success Based More on Seedbed than on Chemicals

HYDROPONICS is the name applied to the science of crop-production in seedbeds placed over shallow basins of water containing chemicals. The roots of the plants grow through the bed into the solution below. It has been found that water changes roots from their soil types, and that the formulation of a new science which would require volumes to explain is based on this root change.

The basis of hydroponics is found in the properties of water and of the seedbed which take the place of the nonnutritive fraction—99.99 plus percent—

of the soil that constitutes the normal home for the roots. The chemicals added to the water substitute for the nutritive fraction of the soil. Successful hydroponics depends largely on arranging the seedbed to the requirements of an altered root system, as described in the author's book, "Complete Guide to Soilless Gardening."

Soilless crop-production has been widely misconceived, as is evidenced by the use of such terms as chemical gardening, nutrient culture, and so on. These misconceptions did great harm to the new science, as they wrongly inferred that the chemicals, instead of the substitutes for the non-nutritive fraction of the soil, determined the dynamics of the method.

Garden vegetables can be grown economically by hydroponics, since land-fertilizer grades of chemicals are entirely satisfactory for addition to the water. Increased production soon compensates for investment in equipment. Any one can be successful in growing garden crops without soil if he bases his procedure on the influences of water and the seedbed, and does not expect miracles from the chemicals.—*W. F. Gericke.*

CORE RESIN
Reduces Demands For Foundry Sand

FACED WITH a scarcity of the specially graded silica sand used in cores and molds to shape tough cast armor steel, foundries have greatly increased their use of mechanically-reclaimed old sand by mixing it with a pulverized resin. Before the war, production of each ton of cast steel usually required half a ton of new sand.

As an illustration of how much sand has been saved for re-use by the inclusion of the resin, the Hercules Powder Company cites one large foundry turning out 5000 tons of steel castings monthly. By using the resin, which is extracted from southern pine wood, this foundry has sliced its new sand requirements from 2500 tons to 600 tons monthly.

The resin core binder has shortened production time because it bakes faster than other type binders and it has been found especially effective with sands containing clays. Truline Binder, the Hercules resin, also provides unusual dimensional accuracy in the sand shapes.

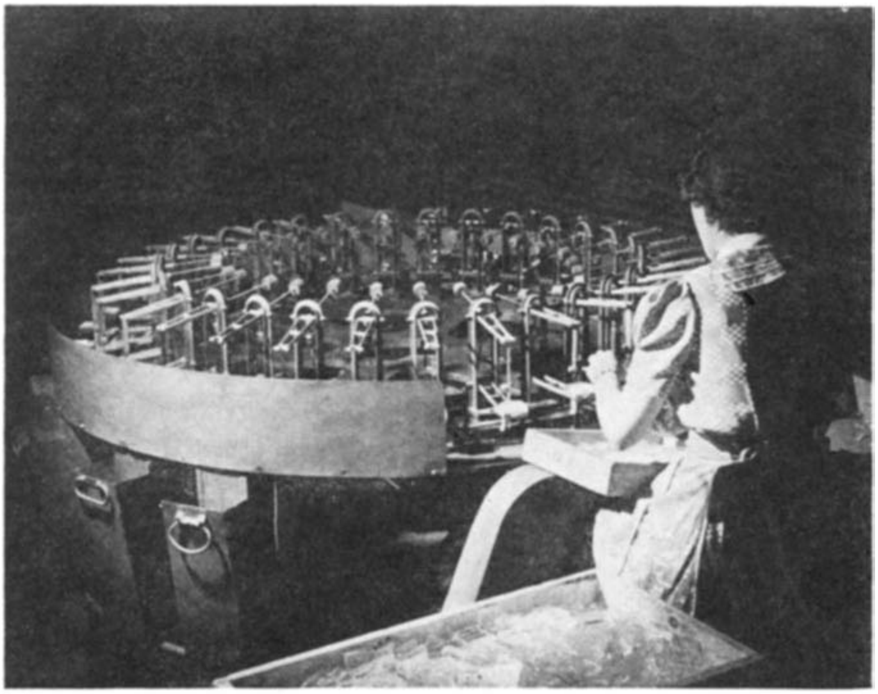
ULTRASONIC WAVES
Are Being Put to New Military, Industrial Uses

IN 1927 Professor R. W. Wood and Mr. A. L. Loomis of Tuxedo Park, first described the physical and chemical effects which can be caused by the application of intense sound waves to various physical, chemical, and biological systems. Since then, high-intensity sound waves of audible and inaudible (ultrasonic) frequency have become, through the efforts of numerous investigators, a valuable tool in many branches of science. One of their main fields of application is colloid chemistry, the science of matter in a finely dispersed state, which deals with emulsions, suspensions, proteins, starch, rubber, fogs, smokes, and other similar materials.

By the application of high intensity sound waves, according to a paper by Professor Karl Sollner, University of Minnesota, presented before the Division of Colloid Chemistry of the American Chemical Society, many materials may be dispersed to form colloidal dispersions. That is, emulsions may be obtained if a vessel filled partially with oil and partially with water is exposed to the action of sound waves of audible or inaudible frequency.

On the other hand, emulsions may be destroyed, "broken," as the colloid chemist says, by sound treatment of low intensity. Many soft, solid materials may likewise be dispersed by sound action to form colloidal suspensions which conventionally are prepared in so-called colloid mills. Scientists of the Bureau of Mines in this country and others abroad have demonstrated that sound treatment of fogs and smokes leads to the aggregation (coagulation) of the droplets of fogs and the particles of smoke, so that they may settle readily, leaving the air clean and free from foreign material. This technique may soon find a wide application in the fight against the smoke nuisance and at the same time allow the recovery of valuable and rare materials otherwise lost through the chimney.

Useful applications of intense sound waves outside the field of colloids in-



Fabric lining for barge gasoline tanks being coated with Thiokol "latex"

clude their marine application in the detection of submerged objects in water, such as icebergs and ships. This is today an indispensable help to navigation in war and peace. Sound waves are also used to test large metal castings for cracks and holes, which frequently cannot be detected by the usual X-ray methods. Gas bubbles or fine fissures prevent the regular transmission of the sound wave in the metal; thus any irregularity in the sound transmission indicates a dangerous weakness in the metal casting.

DRYING OIL

Made from Castor Oil by Simple New Treatment

FOR SEVERAL years prior to the present war some of the manufacturers of paint oils had started to make a drying oil from castor oil. Ordinarily castor oil is a non-drying oil, but by a rather simple chemical treatment it can be converted into an oil which compares quite favorably with China wood oil (otherwise known as tung oil) in its drying properties. This latter oil has for many years been very important in the formulation of varnishes, and shutting off of supplies from the Orient would have been a very serious matter if there had not been this substitute made from common castor oil.—*The Research Viewpoint,* Gustave J. Esselen, Inc.

BARGE LININGS

Protect Gasoline from Concrete Reaction

A NEW job for synthetic rubber—transporting and storing millions of gallons of high-octane gasoline at strategic coastal points and island air bases —is being accomplished by the use of a new synthetic rubber "latex" to line concrete gasoline barges and underground storage pools. The new "latex," or water-dispersion of particles of synthetic rubber, which is resistant to the highest octane fuels now coming into extensive use, was developed by the Thiokol Corporation.

Early in the war concrete barges and tanks were eyed by engineers as a possible solution to the already critical steel supply, but were in themselves useless for gasoline transportation since the alkalies in concrete react to form gum in the gasoline and lower the octane rating. In a new process developed for the U. S. Navy by Stoner-Mudge Inc., fabric of the type used for camouflage cloth is cemented to the concrete with the Thiokol "latex" and coated with the same material. The result is a gasoline-resistant container which protects the contents of the tank from the alkalinity of the concrete and which will bridge over normal cracks in the concrete caused by shrinkage, settling, and unusual stresses.

COAL-TAR FUEL

By-Product of Coke Ovens Used Successfully

SUBSTITUTION of a relatively plentiful fuel in place of oil has effected a saving of 25,000 gallons of fuel oil daily at the Rouge plant of the Ford Motor Company. The substitute is coal tar, a by-product of the Rouge coke ovens.

The open hearth furnaces at the steel mill ordinarily are heated with fuel oil. Substitution of tar, however, involved no mechanical changes, since the heating values of both fuels are substantially the same and both are injected under steam pressure.

WEIGHT SORTING

Accomplished on Balance Merry-Go-Round

SPEEDING up the war effort in the precision lens field is a merry-go-round on ball bearings, carrying an endless procession of balance scales past a single operator, which does the work of 20 individual sorters and weighers in the glass plant of the Bausch and Lomb Optical Company.

Small squares of optical glass, which must be accurately weighed before being molded into lens blanks, are placed on each balance as it passes the operator. The scales are set to weigh within one gram (about one twenty-eighth of an ounce). Attached to the pan of each scale is a trip lever which automatically dumps the glass into the proper bin.

The heaviest pieces are tripped at the right of the operator, with each succeeding bin receiving blanks weighing

Optical glass squares are sorted by weight on this merry-go-round one gram less than the preceding one. A bin is provided to take blanks weighing more than the maximum and another to receive those below the minimum weights.

There are 30 balances on the machine, which makes two revolutions per minute. All the operator does is to place a piece of glass on each scale as it passes. The machine does the rest, sorting each piece by weight.

NYLON ROPE

Exhibits Unique and Valuable Properties

NYLON ROPE, whose unusual properties have demonstrated their value under the severe test of invasion glider operations, can be seen stretching into the future to perform a variety of useful civilian tasks.

In its combination of strength, lightness, and durability, nylon is equaled by no other fiber rope. A nylon rope approximately one half inch in diameter can lift a load of three tons and is about twice as strong as a manila rope of the same thickness. Nylon rope is, furthermore, one half to two thirds as heavy as manila rope of equal diameter. But its peculiar elasticity is the quality which makes it unique.

A rubber band or a steel spring has an elasticity which expresses itself in a quick snap. Nyon rope, in contrast, has a slow, gentle bounce. Under the stress of a sudden pull, the nylon rope stretches rapidly but recovers slowly, the action desired in the perfect shock absorber.

The scientific explanation of this behavior is hysteresis—a lagging or retarding effect due to internal friction. In a sense, hysteresis is the conversion of energy into heat. When you stretch a rubber band the energy you put into the action is stored up in the rubber, ready to snap it back the moment you let go. Energy is similarly stored and quickly released when a steel wire or cable is stretched. But when you stretch a piece of nylon rope, much of the energy goes into heat and only a part of it is converted into recoil, making a smooth shock-absorbing effect.

Its shock-absorbing property gave nylon rope its first job, back in 1940, picking up airmail in a non-stop service operated by All-American Aviation, Inc. Before nylon rope was adopted, a hydraulic shock absorber was used to ease the strain when the mail bag was picked up "on the fly." But the nylon proved to be much simpler, lighter, and more efficient.

When the Army entered the glider program it, too, tried first a mechanical shock absorber, with steel cable on the glider nose and on the pick-up winch. But the Army eventually hung its hopes on nylon rope.

Most of the glider operations to date, including the transatlantic cargo trip and Sicilian invasion, have been straight tow maneuvers in which plane and glider leave the field together. But non-stop pick-up has been demonstrated many times, with large as well as small gliders, and nylon rope has turned in a successful performance. Pickups are seen as particularly useful for rescuing isolated troops or wounded men from a spot too cramped for a plane landing, or for moving fighters from such a point to the next assignment. A glider could be landed in the small area and then picked up after loading.

Some of the climbing ropes employed by the Army's mountain troops are also of nylon, which provides strength with less weight and is thus easier to carry. Nylon likewise absorbs much less water than does manila, another weight advantage in rainy weather. The shock-absorbing property is an obvious benefit when a soldier slips and is checked in his fall.

The post-war world should find nylon rope's opportunities greatly broadened. There are applications on file from 1800 towns and villages who want non-stop airmail service, and availability of planes after the war should permit this expansion. The late Richard du Pont foresaw, and his associates of All-American Aviation, Inc., still see, room for cargo and passenger gliders serving as feeder lines for the larger airways. Powerful tugboats of the air could pick these up non-stop at the small towns and drop them over landing fields of the through airlines.

These and other applications of nylon rope would benefit by its high resistance to abrasion, which makes it outwear manila. After a million rubs across a metal bar, in abrasion tests, nylon was still good, whereas manila wore out in 200,000 rubs.

Nylon's resistance to the damaging

effects of mildew and salt water, in addition to its strength, lightness, and elasticity, suggest many other post-war applications for nylon rope. But actual trial in many new tasks must await the day when there is no longer such a heavy demand for nylon yarn in its major job—helping to win the war.

STURDY FLOORS
Made of Specially Designed Panels

A LIGHTWEIGHT floor, which is also sturdy and capable of withstanding a lot of abuse and scuffing, consists of a top surface of a plywood known as Ply-Tech, a bottom surface of the same material, and a core of spruce wood, made

Weight test of new floor panels

up of narrow grid strips. The result is a floor panel less than ¾-inch thick, with a weight of approximately .85 pounds per square foot, that will support an ultimate load of 800 pounds per square foot on 18-inch spans. Since the core of this floor is hollow, provision is made for necessary bolt holes by dropping small blocks of wood into cubicles of core before pressing, thereby giving solid construction where necessary.

Hollo-Tech, as this type of floor is called, presents its best strength factors when made in large panels. Floor panels up to 25 feet long and 4 feet wide are being made. The continuous length over a multitude of supports lessens the possibility of deflection due to unequal loading of spans.

GEAR SHAVING
Shows Notable Savings Over Grinding

A SAVING of 40,000 man-hours a year in the production of vital Flying Fortress engines was announced recently by The Studebaker Corporation. The economy results from an application of shaving machines to a 15-tooth pinion gear which is carried in sets of 20 on each Wright-designed Cyclone. Important machine conservation and reduction in scrap is likewise reported for the revolutionary method.

According to George W. Bunner, general manager of the Fort Wayne Studebaker aircraft engine parts plant, a single worker on gear shavers can produce as many units as five on grinders, until now the conventional machine for shaping finished aircraft engine gear teeth. Scrap has been all but eliminated by the fact that in-built precision of the shavers reduces the possibility of human grinding errors.

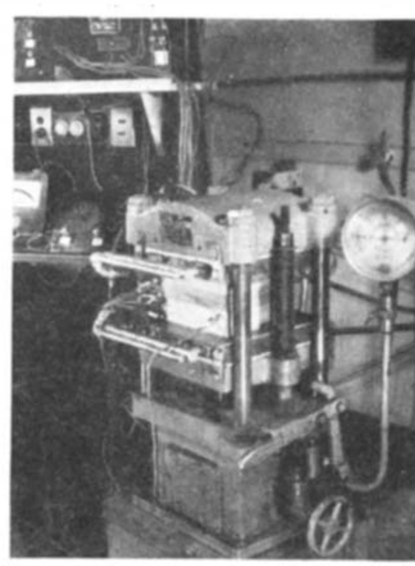
With conventional gear grinders, it is necessary to re-form the grinding wheel after every piece; the high speed steel cutting tool used in the shaving machines is reported to be good for 5000 pieces and each tool will take four re-grinds. A run of 25,000 pieces is thus possible before replacement of the tool.

WOOD GLUING
Speeded by Application of Resistance Heating

SHORTENING the assembly period during the manufacture of laminated timbers from a week to about five minutes, with a better quality of gluing, a new gluing method was recently announced by Dr. W. Gallay and Mr. G. Graham of the Division of Chemistry, National Research Council, Ottawa, Canada. The method has already been tried out on a large scale and will be ready shortly for commercial use. It consists essentially of a novel means of generating heat directly in the glue line in order to set the adhesive irreversibly.

This is accomplished by adding a conductor—acetylene black—to the glue so as to render the glue line conductive. Electrodes placed along the edges of the glue lines are connected in parallel, and the glue is then heated by low-voltage current of ordinary characteristics, such as D.C., 60 cycle A.C., and so on. The heating is essentially similar to that in a toaster or heating pad. The method is very simple, requiring no apparatus, no plant conversion and no trained personnel, and is to be sharply distinguished from radio frequency heating from which it differs entirely, and over which it has advantages for gluing large-scale work.

The quality of the bond obtained with resistance heating is very good, and large scale trials conducted in an air-



Resistance heating set-up for gluing

craft plant have shown that the procedure is rapid and efficient.

The new process, it is expected, will open a new field of utilization for laminated wood, not only for many important war uses, but also for general construction and engineering application in post-war uses.

GAS DETECTOR

Uses Photocell of Limited Response

A VIGILANT "safety patrolman," with an electric eye that can see the ghostly shadows of many otherwise invisible gases and vapors, has been developed by Du Pont scientists to warn of dangerous concentrations of these compounds in the atmosphere of manufacturing plants.

Known as an ultra-violet photometer, the instrument is faster and simpler than analyzers previously used and it is so sensitive that it can detect one part of carbon disulfide, for example, in a million parts of air. Similarly faint whiffs of other volatile compounds are quickly detected by this electrical watchman.

The problem of contaminated atmospheres is one with which many industries are concerned. Elaborate air-conditioning systems, special section hoods, and so on, are employed in plants to draw vapors and gases, and in many situations the workers themselves wear gas masks during certain operations.

It is necessary, however, to make periodic checks of the air in various parts of the plant to ascertain whether the concentration of the volatile substance is being held within the safety level.

Most analyzers previously employed required 15 minutes or more to take an air sample, which therefore represented only the average concentration of the gas during that period of time. Momentary high peaks escaped observation. The instrument developed by Du Pont, on the other hand, can take quick "grab samples" or run continuous samples and give direct and instantaneous readings. This permits accurate second-by-second observation of the vapor level in each step of a manufacturing process. For this reason boards of health, insurance companies, and industrial engineers have found the analyzer helpful in determining hazards and in arranging equipment and planning air-conditioning systems and exhaust flues to render working areas safe.

V. F. Hanson, of the Electrochemicals Department of Du Pont, designed the original instrument and a modified model, intended particularly for carbon disulfide analysis, has been developed by Dr. Shirleigh Silverman, assisted by Dr. J. W. Ballou and W. H. Warhus, all of the Rayon Technical Division of the company. The Mine Safety Appliance Company is planning to manufacture instruments of this general type.

Operation of the ultra-violet photometer is based on the phenomenon of light absorption by gases. Most gases, including the constituents of the air itself, absorb light of some particular wavelength and thus throw a shadow where light would otherwise have fallen. In a spectrum that shadow is known as an absorption line.

Carbon disulfide, for example, strongly absorbs light having a wavelength of 3132 angstrom units. (An angstrom unit is equivalent to 39 ten-billionths of an inch.) Light of this wavelength is in the ultra-violet range, invisible to the human eye but not to the electric eye, which in the case of the analyzer is a sodium photocell.

The carbon disulfide analyzer is so constructed that the air to be analyzed is pumped through several small chambers, which filter out dust, oil, and moisture, and thence into a pair of parallel tubes, about 31 inches long. The contaminated air runs into the first tube and then through a canister of activated charcoal which removes the carbon disulfide and passes the purified air into the second tube. In this way there may be a continuous comparison of the purified with the contaminated air and very minute differences may be detected.

Rays of invisible ultra-violet light from a mercury lamp pass through the two tubes and fall upon a photocell mounted at the opposite end of each tube. The optical system, including filters, has been so selected that about 60 percent of the photometric response of the cell is due to light 3132 angstrom units in wavelength, the light which carbon disulfide absorbs. No other atmospheric element has been found in plants where this instrument is used that absorbs either this band of light or the 3650 angstrom unit band, which accounts for most of the remainder of the photocell's response. Therefore, when the analyzer "bats its electric eye" the operator knows it has seen the "shadow" of carbon disulfide. One part of this vapor in a million parts of air will produce an absorption of .02 of 1 percent, which is detectable by the instrument.

As an example of how the analyzer is used, Dr. Silverman cites a test in which 61 readings were made during the nine minutes required to open, dump, and clean out a large vessel in which material was treated with carbon disulfide. During most of the operation the concentration of gas remained below 20 parts per million and older methods of analysis, which could give only the average for this entire time interval, would show no danger points. However, the watchful photocell revealed that the concentration rose to 60 parts per million at one moment and to 40 at another. The ventilating equipment was therefore modified in order to eliminate these peaks.

TURBINE BLADES

Radically Improved After Long Research

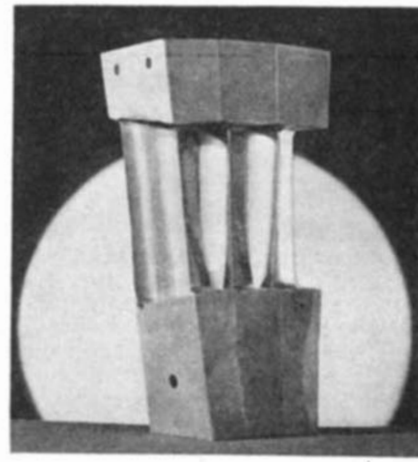
SOME studies of turbine impulse blades begun four years ago have been completed. A great deal of engineering drama and much of peace-time technical significance lie behind those words.

The middle 30's saw the size of high-speed (3600 revolutions per minute) steam turbines, for superposition over existing units in power houses, being rapidly increased. In three years the largest size of this type was extended from about 15,000 to approximately 50,000 kilowatts. Steam engineers, in crossing these new frontiers, found themselves faced with new conditions. Impulse blades made correspondingly stronger, according to previous practice, were not strong enough. The established design rules no longer held in these new regions of temperature, pressure, vibration, and so on.

As a result, Westinghouse inaugurated a long, painstaking program of theoretical and laboratory studies. A special test turbine was built and a unique scheme was devised for taking photographic records of blade behavior with the turbine in actual operation. In this four-year study several types of blades have been tested using a wide variety of temperatures, loads, and speeds. Long endurance runs have been made and about 120,000 photographic records were taken on about six miles of film.

Out of this enormous mass of engineering data has been evolved a superior, yet very simple impulse blade. The root by which it is fastened to the turbine rotor is shaped like an inverted U. Three of these blades are brazed together, forming one solid segment. Each three-blade segment is fastened to the rotor by two crosswise pins.

The new blade is smaller than the old one—one and one half inches wide instead of two. Old-design blades (which are larger) failed in less than 20 hours under grueling tests—the new



One segment of new turbine blades

blades pass a life test of 1000 hours with no indication of weakening. Experience shows that if a blade fails at all, it will do so in a relatively few hours. Fortified with a great deal of new design information about impulse blades, turbine engineers are ready to move to new levels in turbine construction when the central-station industry needs—and is able to obtain—larger, more powerful, high-speed generating units.

"SECONDARY" CHEMICALS

Required in Huge Quantities for Synthetic Rubber Production

THE CURRENT Government program calls for the annual production of 850,000 long tons of synthetic rubbers: 735,000 tons of GR-S (Buna S); 75,000 tons of GR-1 (Butyl); and 40,000 tons of GR-M (Neoprene). In addition, smaller amounts of Buna N, Chemigum, Hycar, Koroseal, and Thiokol are being manufactured by private companies. Aside from the chief constituents—butadiene, styrene, isobutylene, isoprene, and chloroprene—many other chemicals are required, and although their proportions are small, the total amounts are great. In the processing of the synthetic rubbers, moreover, still other substances are needed; some of these are the same as those used in processing natural rubber, but in greater proportions; some are quite different. The total amounts of all these "secondary" chemicals reach staggering figures.

These additional chemicals are both inorganic and organic. Large amounts of alum and soda ash, for example, are required to soften the water used in the polymerization process; sodium metaphosphate is used for preventing corrosion in pumps, pipe lines, and tanks; chlorine is employed to keep down slime formation in apparatus; anhydrous ammonia and brine are necessary to furnish refrigeration; tons of rock salt and much sulfuric acid are used in solution to precipitate or coagulate the synthetic latex.

Organic stabilizers, little-known compounds which prevent the premature polymerization of the butadiene and styrene while in storage, are present in only about 0.02 percent. Yet on the basis of 748,600 tons of butadine, this small proportion means about 150 tons, or a third of a million pounds. Furthermore, these stabilizing agents must be removed before the material is emulsified, and for this a solution of sodium hydroxide is required.

The emulsification of the butadiene and styrene requires great quantities of soap—pure sodium stearate. The plants are designed to use soap itself or to make the soap from stearic acid and sodium hydroxide. The polymerization catalyst is added to the emulsified materials, and later a reaction stopper or anti-polymerizing agent is used to arrest the polymerization at the proper stage. This reaction stopper may be an antioxidant and therefore serve a dual purpose.

Larger proportions of softeners are generally required in GR-S than in natural rubber. If at least 5 percent of a softener is used in every GR-S compound, the total amount would be 36,750 tons or somewhat over 82,000,000 pounds! Softeners must be cheap and the important ones come from coal tar and turpentine products. High-boiling esters such, for example, as dibutyl phthalate, dibutyl sebacate, and so on, are in favor in the processing of some of the synthetic rubber compounds.

Organic accelerators are important in the vulcanization of GR-S compounds, as with natural rubber. There are variations in the effects obtained, but mercaptobenzothiazole is the leader in both cases. Tetramethylthiuram-mono-sulfide and mercaptothiazoline are also useful. The aldehyde-amine type of accelerator, like the butyraldehyde condensation product with aniline, acts best as a secondary accelerator to "boost" the action of those just mentioned. From 1.0 to 1.5 parts are generally used to 100 of the synthetic rubber. On the basis of 735,000 tons of GR-S, 1 percent means 7350 tons of accelerators.

In the manufacture of Butyl rubber, boiling ethylene is used to refrigerate the reaction mixture. The manufacture of Buna-N requires sodium oleate as the emulsifier, salt for the coagulation, and antioxidants for stopping the polymerization. Furthermore, reclaimed rubber is closely connected with the entire program and the amount now being made is almost double the pre-war production. Here caustic soda and oils from the coal and pine tar industries are widely used.

"Research is the price of progress," and surely at this time, with the wonderful co-operation of rubber chemists and engineers in the great synthetic rubber program, we can expect marvelous advances in rubber technology, and the application of many new chemicals to make the synthetic rubber do even more than natural rubber could do.—*U.S.I. Chemical News.*

FUNDAMENTAL KNOWLEDGE

But Little Advanced by War-Necessitated Research

ALTHOUGH the war has been responsible for many new inventions, it has added little to the world's store of fundamental knowledge, Dr. Frank B. Jewett, vice-president of the American Telephone and Telegraph Company, recently told members of the New York University Institute on Post-War Reconstruction.

According to Dr. Jewett, only a few of the many technical discoveries which have been made since the war began will have peace-time applications. Progress in certain fields of scientific knowledge, he said, has been offset by a virtual cessation of research work in others that are not considered essential to the war effort.

"While the war effort has produced astounding technological results in many sectors it has on the whole added little to our store of fundamental new knowledge." Dr. Jewett said. "In the main it has been an intense utilization of accumulated knowledge and skills for a particular limited objective. Much of the result has little prospective use outside of the domain of warfare."

Describing scientific progress in peacetime as a relatively orderly process in which research workers benefit from a continual interchange of knowledge, Dr. Jewett pointed out how the advent of war interrupts this process, stimulates certain fields of research at the expense of others, and prevents the dissemination of scientific information.

"When war comes," Dr. Jewett said, "certain sectors of science and certain technological applications take on primary importance in the program of mass destruction or defense against it, and other sectors are for the time being of little or no importance in man's struggle to survive and conquer. Research work in these latter fields tends to dry up and cease. General training for research and broad technology diminishes rapidly and highly specialized training for immediate productivity in new instruments and instrumentalities of war takes its place.

"Even in those sectors which are indicated fields for warfare, fundamental scientific research soon becomes a rarity—the tempo of war is too great to admit of squadering manpower on an adventure of such long duration and so uncertain of results that it can not be usefully employed in the current struggle.

"Further, since real training in science and technology equips a man for many things outside his particular specialty, there is a tremendous pressure to transfer men from fields of lesser to those of higher promise in the art of killing. Likewise, the conditions which are mandatory for general scientific progress disappear. There is no longer any intercourse between the scientific worlds of the warring nations and a minimum even of free interchange within the nation itself. Every one is bound by rigid rules of military secrecy and, despite heroic efforts to disseminate helpful information without breaking these rules, a large amount of work has to be done in essential watertight compartments and in ignorance of much that would be helpful.

"A war effort as vast as the present one, if long continued, accentuates all these tendencies and dislocations immeasurably. The whole thing is an undertaking which destroys progress in basic scientific knowledge and in the application of that knowledge to the general betterment of society. In some directions there will be astounding technological development while in others there will be little or none. Even where development has been great, much of it is likely to be of little use to society since it is concerned exclusively with items of warfare which have no normal counterpart in peacetime needs."

Among the fields where scientific progress has benefitted from a war-occasioned stimulus, Dr. Jewett mentioned aeronautics, electronics, the development of substitute materials, and medicine.

"By far the greatest technological post-war problems have to do with man himself in solving his adequate adaptation of technical knowledge to mass utilization for beneficent purposes," Dr. Jewett said.

POST-WAR WOOD

Demands Will be Greatly Increased

THE SOUTH will be called on to supply about one half of the nation's future timber requirements, now estimated at 21 billion cubic feet, according to Lyle F. Watts, chief, Forest Service, United States Department of Agriculture.

Watts says that the nation appears to be entering upon a new era of wood, with many new uses opening up in the field of chemistry and new engineering techniques enabling wood to hold its own in competition with other building materials. For the period immediately following the war, he says that reconstruction requirements abroad hold promise of greatly increased export markets.

If these needs were to be supplied, Watts says, it would be necessary to double the annual growth in the southern states, since even before the forests were subjected to stepped-up wartime cutting annual growth was estimated at 5.6 billion cubic feet, or only about half the post-war output to be expected of them. Sawtimber drain is already almost twice current annual growth. In this doubling of the productivity of its forests, he adds, lies the chief hope for much of the industrial expansion now "so eagerly sought by the South."

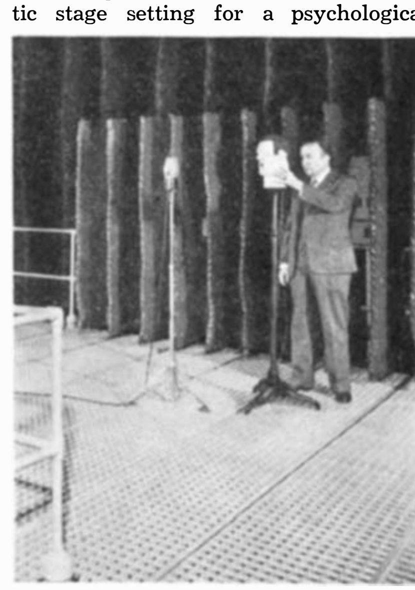
The chief forester advocates public regulation of cutting and other practices on privately owned forest land as indispensable, if prospective post-war production goals were to be met. The type of regulation urged by the Forest Service would provide for direct Federal action only when and where a state failed to enact and enforce suitable legislation. From the standpoint of sheer self-interest, Mr. Watts points out, the South should welcome this aid and stimulus.

QUIET, PLEASE

Might be the Slogan of a Free Field Sound Room

THE "quietest room in the world," which was built to make possible accurate measurements of sound and performance of radio and sound equipment, was described in a paper recently presented by Dr. Harry F. Olson, of the RCA Laboratories, before the Society of Motion Picture Engineers.

Looking more like a weird and fantastic stage setting for a psychological



Sound-reflection effects of a speaker's face and head when close to the microphone are checked, in the RCA free field sound room, with this robot. Musical tones, produced by an audio oscillator, issue from the "mouth" and are trapped by lined walls and baffles drama than the scientific workshop that it really is, this "free field sound room" is used to provide the necessary conditions for making accurate acoustic measurements required in the development of microphones, loudspeakers, and other electro-acoustic equipment.

Standing on a grilled platform, midway between an unseen floor and an unseen ceiling, looking into depths of shadow on all sides and above and below, a visitor in this strange room might for the first time hear his own voice—or any other sound—as it really is, without the distortion ordinarily caused by reflected sound and by the intrusion of direct sound from other sources.

But if this visitor—perhaps a nerve-wracked refugee from the screech of subway trains and taxi brakes and the rest of the bang and clatter of city life—should care more for quiet than even the true sound of his own voice, he would experience a silence more ominous and oppressive than the shadows brooding among the deep baffles of sound-absorbing material lining the room, a silence in which he would hear the small sounds produced within his ears by the living processes of his own body.

Chiefly responsible for the shadows as well as the quietness are baffles which extend into the room from all of its surfaces. They consist of strips of Ozite, one inch thick and alternately seven feet deep and four feet deep, placed at right angles to the walls, ceiling, and floor, and spaced one foot apart. Behind these are sheets of one-inch Ozite placed parallel to and one foot removed from the walls, ceiling, and floor. The function of these baffles may be visualized as that of sound traps, for sound waves entering them are annihilated, and none escape but those which are too long for the depths of the baffles.

FARM FACTORIES

Forseen for the Post-War Future

THE FARMER of the post-war period will be an industrialist as well as a producer of raw materials for industrial purposes, D. Howard Doane, of St. Louis, predicts in *Farm Journal.*

Doane, the nation's leading professional manager of farms, with 350,000 acres under his supervision, says: "The next and biggest step in agriculture is establishment of fixed and movable processing plants, handling agricultural products grown near by, which will extract, compress, dehydrate, refrigerate, concentrate, and fabricate these farm commodities."

Products which offer the best possibilities for processing in rural industries are those which are bulky, full of water, or perishable; or those where a large number of handlers have crowded between producer and consumer. Some of the processing will be done on individual farms, some by farmers' co-operatives, some by private companies, including rural branches of city industries.

Doane calls the new program "vertical diversification," explaining this to mean that, instead of raising many kinds of crops, known as "horizontal diversification," the farmer will concentrate on his most profitable crop, and make it as nearly ready for the consumer as he can.

GADGETS MUST WAIT

Volume Goods Will be First in Post-War Period

FEW OF the startling mechanical "gadgets" born of war's speeded-up research will be coming off production lines in the immediate post-war period, states Dr. H. E. Fritz, research director of B. F. Goodrich Company, because employment needs will demand big-volume production of those goods for which industry already "has the tools."

To emphasize the magnitude of the problem the nation will face in maintaining jobs when war work is finished, Dr. Fritz points out that 1944's estimated production of war goods alone—$80,-000,000,000—will be the equivalent in dollars of "200 Panama canals, so you see that during 1944 we will be producing the equivalent of a little better than one Panama canal every two days."

The need for speed and volume in "compensating" peace-goods production will be so great, he adds, that there will be a considerable period after the end of the war before many of the war-born mechanical innovations can reach the market.

Among things "we may expect" in the post-emergency years Fritz lists: A cloth-like material which needs no weaving, made from mixtures of natural and synthetic fibers by a paper-making technique; non-shatterable glass and glass fibers with tensile strength of 3,500,000 pounds per square inch, 10 times that of malleable steel; a chemical which provides a sort of invisible raincoat for anything that is dipped in it, without there being any visible film on the fabric; and hundreds of new rubbers and rubber-like materials "performing unique and unexpected jobs and made from wheat, corn, garbage, soybeans, coal, petroleum, limestone,

milk, sweet potatoes, and even salt."

"In order to meet consumer needs and furnish jobs, our factories for some time after peace comes will turn out models not greatly different from the pre-war ones, using old patterns, jigs, and dies," he says. "Once the 'old' models are in production and people are back at work on peacetime jobs, the psychological hunger to purchase will begin to taper off. That will be the time to begin offering the new gadgets and things to keep the process going. At this point new marvels of science will begin to appear.

"Some research people may feel this is a step backward, but we must recognize that it is far more important to keep unemployment to a minimum than it is to furnish the public with new gadgets that will take time to develop, let alone get into volume production. After all, many of the pre-war things were pretty good, too."

Dr. Fritz describes as the "paratroopers of industry" America's research chemists and physicists who have wrested world leadership in research and development from Germany. "Many comparatively new American machines and instruments," he says, "are proving their superiority in the fiery crucible of war in spite of the fact that the enemy for many years has devoted much time and skill to devising instruments of destruction while Yankee ingenuity was concentrating on better standards of living, not standards of killing."

FILTER OF RUBBER

Made by Exploding Trapped Air

THOUSANDS of lives are now being saved because 18 years ago the laboratories of United States Rubber Company made a leaky raincoat. So states Herbert E. Smith, president, in telling of the development of Multipore, a filter material with as many as 6400 holes to the square inch, now in use in the preparation and administration of blood plasma.

"This versatile material," Mr. Smith says, "is also filtering fruit juices for shipment to combat areas. It is serving in the purification of insulin, aiding in the production of magnesium, increasing the output of coal and steel, and speeding up the production of four-engine bombers.

"Multipore may be traced back to the day 18 years ago when our laboratories were pioneering in the use of natural rubber latex for waterproofing raincoat fabric," Mr. Smith continues. "Pinholes, almost microscopic in size, mysteriously appeared after the fabric had been heated in the drier. These holes were found to be the result of small explosions. Pockets of air were being trapped within the mesh of the fabric, and when they were expanded by the heat they exploded through the films of latex that had been spread on the fabric.

A blood-filtering rubber disk

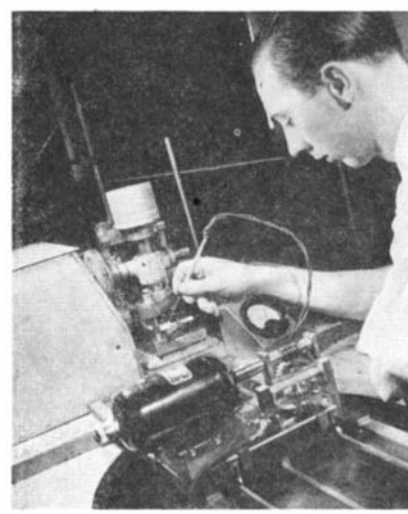
"A remedy was immediately found, before the raincoats went into production, but our scientists didn't stop there. They took a fresh start in the opposite direction to see just how many holes they could shoot through a square inch of latex film. They succeeded in blowing as many as 6400 holes to the square inch, in sheets up to 42 inches wide and 20 yards long—and created Multipore."

These filter screens are made of either hard rubber or soft, and may be compounded to resist abrasion, high temperatures, alkaline and acid solutions, and certain oils and greases, it is stated. Since they are made only from natural rubber latex of the Hevea tree, now one of the most critical of all materials, the filters can be applied only to the most important products.

GLASS JEWELS

Produced in Quantities for Use in Instruments

TINY sapphires threatened to hold up production of instruments at the beginning of the war. An absolutely essential part of our vast airplane program, millions of electrical instruments awaited a substitute for the jewels formerly supplied from factories of Switzerland, blockaded by the Axis. According to Westinghouse engineers, a way has been found to make these vital instrument jewels of glass. At first they were made slowly, by hand, one at a time. At best, a worker could make about 1200 a day, of which many were imperfect.



Machine for making glass jewels

Now they are turned out by automatic machines at the rate of 3500 per day. Not only that, but one operator can tend two machines that produce almost no poor jewels. This glass-jewel development wiped out a threatened war-production bottleneck and produced a better product. For many types of instruments, engineers now prefer the jewels of glass to those of sapphire.

New Products

MARKING MACHINE

A NEW rotary marking machine for high-speed production marking of machine tool parts that can be rolled meets all safety requirements and does difficult marking formerly accomplished only with large special equipment.

Driving power is furnished by a 1½ horsepower-gear reduction motor with extended shaft on which is mounted the marking roll. The oversized shaft is supported by two heavy pillar blocks with heavy roller or ball bearings to support the marking strain. Switch box on the machine controls the motor and a transparent Lucite removable guard covers the marking roll for safety.

For high-speed production marking

The wedge type cradle rolls are controlled by a hand lever that brings the work into marking position against the continuous rotation of the marking roll.

SLOW-HITTING HAMMERS

TWO SIZES of a completely new line of slow-hitting aircraft riveting hammers are now in production. These new hammers are notable for their power, control, smooth operation, and ease of handling, and have a number of features such as a two-finger trigger, a metered air throttle valve, an improved offset handle, good balance, and compact design. Women riveters, especially, find that they can operate these Forss hammers more easily, and do more and better work with less fatigue.

COMBINATION DUST COLLECTOR

PORTABLE and self-contained is a new dust collector of the cyclone-filter type for exhausting dust- and dirt-laden air from most types of medium-heavy abrasive operations, announced by Aget-Detroit Company.

The new unit contains a multiple-blade fan direct-driven by a continuous duty motor, a removable spun-glass filter, and a cyclone type separator. This combination allows the cleaned air to re-circulate into the working space for big reductions in heating losses.

Continuous duty operation of the new unit on medium-heavy dust collecting operations, without frequent changing of the filter, is possible because of the high efficiency of the cyclone separator which removes most of the dust and dirt before the cleaned air is returned to the working space through the filter.

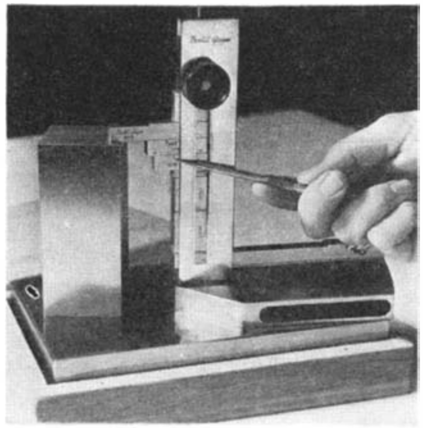
Recommended for collecting dust from production grinding operations on big-wheel surface grinders as well as medium-sized double-end grinders, disks, cut-offs, emery and belt sanders, the new unit is said to be the most compact dust collector of the cyclone separator type available.

A glass jar stores the collected dust; glass is employed so that it can be easily determined when it is full and so that it need never be removed until it is full. Doors on both sides of the cabinet permit ready access to the dust storage.

VERNIER GAGE BLOCKS

GAGE blocks, whether in small toolmaker sets or large complete sets of over eighty blocks, have heretofore been limited to combinations which could be made in increments of one ten-thousandth of an inch. Now the new DoALL vernier gage simply and effectively extends the range of combinations of sizes which can be made with any set of gage blocks by enabling combinations to be made in steps of ten micro-inches and to the same degree of accuracy as provided by precision gage blocks.

The added versatility of a set of gage blocks used in combination with the DoALL vernier gage greatly reduces costs of producing special gages where the dimensions must be held to high accuracy. Gage blocks in combination



A taper is the secret

with the vernier gage can be quickly set up to produce practically all types of snap gages, height gages, and depth gages to millionth-inch accuracy at a fraction of the cost of a special gage. The gage, while of the highest precision, is extremely simple in construction. It consists of two gage blocks having a precision taper on their mating faces. When the taper faces of two blocks are wrung together with their taper index marks coinciding, the blocks form a gage block whose height is 0.700 inch. One block is graduated into ten equal parts between the index graduations. By sliding this block to the right, the height of the vernier gage is increased ten millionths of an inch for each graduation because of the taper. Sliding the block to the left, the height of the vernier gage is decreased ten millionths of an inch for each graduation. The gage has a total range of one ten-thousandth of an inch plus or minus, thereby enabling dimensions to be made in increments of ten millionths above or below any dimension which can now be made with a standard set of precision gage blocks.

PAYROLL CALCULATOR

OVERTIME, as well as straight-time payroll calculations, can be figured in a jiffy with a new and improved model payroll calculator now being manufactured by the Berger-Brickner Company. Forty hours plus overtime are calculated in one operation on one side of the device for firms that require total pay check only. The reverse side is used for figuring straight time and overtime as separate items.

All hourly rates of pay from $.40 to $1.74, with a half cent spread between rates, and time periods up to 80 hours, with divisions of tenths and quarters of an hour, are covered by this inexpensive calculator.

FLOW GAGE

ACTUATION of the indicating dial of a new continuously indicating flow gage is brought about by the kinetic energy of the fluid flowing through the gage. Briefly described, its mechanism consists of an indicating dial constructed as an impeller, the rotary movement of which is resisted by a precision torsion bar. The Flogage, as the instrument has been named, is insensitive to changes in fluid viscosity, fluid temperature, or fluid pressure. It is accurate to within a fraction of 1 percent and can be constructed to withstand any internal pressure without affecting its accuracy.

Design and construction of the unit are adaptable to any flow indicating problem. Provision is made for fittings, top and bottom, which, together with a bracket that is cast en-unit with the center structure, facilitate installation.

MULTIGRAPH TYPE

PRINTING that looks as if it were produced by letter-press can now be done on a Multigraph machine. The type is cast in bars, similar to Linotype, each line in one unit. Sharp, new, clean-cut bars are supplied in typewriter type or "print-shop" type faces and sizes, and the multigraph job is done by regular office help.

It's a matter of minutes only to transfer the type lines from the subdivided mailing box in which it is received to the Multigraph drum, ready to run. The type may be kept on hand in special boxes for repeat usage if desired, or may be returned for metal credit.

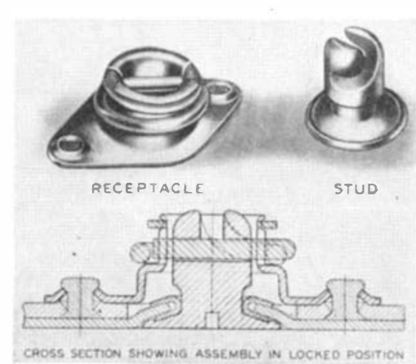
CUTTING OIL COMPOUND

FOR USE in cutting hard high-speed tool steels, chrome molybdenum, and the new National Emergency Alloys, a new cutting oil is a mixture of animals oils and other chemical ingredients. It is claimed by the manufacturers to increase tool life from two to six times before regrinding is necessary; to increase production from 25 to 100 percent by allowing a much higher cutting speed; to reduce over-heating; and to give a finish far superior to any other cutting oil compounds.

This new cutting oil was developed in the shops of the Fearless Tool Company for tapping chrome molybdenum nuts and other parts. It should prove of interest to those manufacturers who are having difficulties in tapping. It is particularly recommended for tapping operations where difficulties are experienced in getting clean threads or where higher cutting speeds are needed.

SPRING-LOCK AIRPLANE FASTENER

A NEW spring-lock fastener is a lightweight unit of extremely rugged construction, particularly suited for holding the engine cowlings of high-speed war planes. In addition to its important uses on airplanes, this fastener is suited to



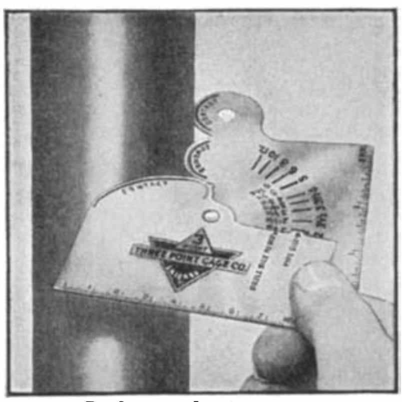
Vibration-proof lock fastener

many post-war commercial applications, such as access plates on farm machinery, panels on motor trucks, home heating units, radio equipment—any point where a quick-acting, vibration-proof, non-rattling fastening is needed.

PIPE GAGE

A POCKET sized, three-point pipe gage for instantaneous measurement of all sizes of pipe from 1/8 inch to 12 inches consists of two pivoted steel plates with edges curved at three points for contact with the pipe to be measured, together with a scale which automatically registers not only the pipe size in terms of inside diameter but the drill size for tapping.

By placing the two fixed contact points of one plate against the outer



Pocket-sized pipe gage

contour of the pipe and sliding the second or moveable plate until it makes the third contact, the marker on the face of the gage will show accurately the size of the pipe. It is necessary to contact only a small section of the pipe contour in order to obtain a measurement.

INSULATED PINION GEARS

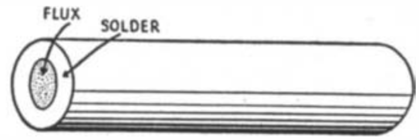
INSULATING pinion gears from shafting by means of a bushing of rubber placed directly between gear and shaft to stop transmission of noise, shock, and vibration, is a development just announced by Bushings, Inc. The new process, which is both simple and foolproof, has important advantages of extreme low cost and elimination of two machining operations normally required for milling keyways or flats.

No special preparation of shafting or gear is demanded by the new process. The synthetic (or rubber), after it is in position, provides a mechanical bond with the bore of the gear and the surface of the shafting of sufficient strength to transmit the required torque.

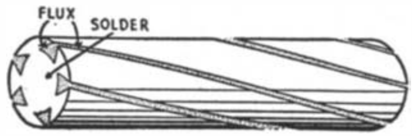
FLUXED SOLDER

A NEW type of wire solder, which contains flux in longitudinal grooves on the surface rather than in the conventional core, has just been placed on the market.

The new material, called Fluxrite and put out by National Lead Company, is said to overcome an inherent disadvantage of regular cored solders which supply flux and solder to the surface simultaneously. Since the flux in the new product is outside rather than in-



CONVENTIONAL FLUX-CORE WIRE SOLDER



NEW-TYPE OF WIRE SOLDER WITH FLUX IN GROOVES

The old and the new

side, it liquefies and flows onto the work *before* the solder melts. This insures thorough and complete fluxing and results in stronger and better soldered joints.

This product, which contains a recently developed special flux, comes in the same diameters as regular cored solder. It is available in two compositions designated as Red Stripe and Green Stripe. These designations refer to the color of the flux which has been specially dyed in each case for easy identification.

UNIVERSAL CENTRIFUGAL CLUTCH

A NEW type of automatically engaging and self-disengaging centrifugal clutch can serve either as a coupling between shafts or as a driving pulley or gear in a transmission, as well as a starting cushion between power units and driven mechanisms.

This new unit, which is known as the "Torkontrol," consists of a partially filled oil chamber fitted with a freely rotating hub, which carries a series of movable wedge-shaped flyweights. As the hub revolves these weights fly outwardly and engage the internal rims of the outer case, binding the hub and shell into a functionally solid pulley or coupling.

The unit works equally well in either direction and is "set" to engage or release at a given speed, and to slip in case of overload.

The manufacturer, Amalgamated Engineering and Research Corporation, claims that this unit permits the use of smaller engines or motors which start without load, gives smooth cushioned application of power and straight-line acceleration with resulting savings in operating cost.

PLASTICS CLEANER

REMOVAL of gummed paper from plastic glass sheets and formed parts is expedited by the use of a new chemical compound, Turco Plasti-Clean, which has been formulated for this special job.

Heretofore, aircraft factories have experienced considerable difficulty in removing the tightly glued masking paper which covers the sheets and formed parts when they are delivered from the manufacturer. If this glued paper is allowed to remain on the plastic for any length of time, or is exposed to heat or sunlight, the paper vulcanizes to the plastic glass and virtually becomes a part of it. Naphtha solvents when used for this purpose often cause "crazing."

Removal of the masking paper with Turco Plasti-Clean, however, is a safe and thorough method, according to the manufacturer. Plastic sheets and formed parts are simply soaked in a tank full of the compound until the gummed paper is loosened, when it is easily peeled off. Turco Plasti-Clean is recommended for Plexiglas, Lucite, Plastacele, Acetate, Pyralin, and all transparent plastic glasses.

LEAD PLATING

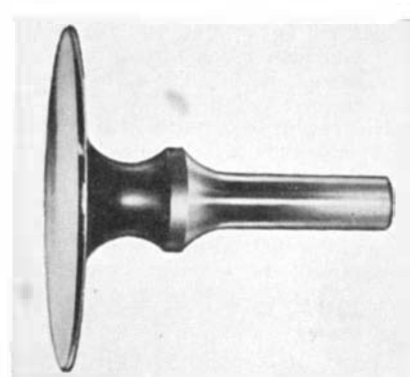
FOR THE protection of iron and steel against corrosion and to obtain a corrosion-resisting coating on non-ferrous metals, electro-deposited lead has been used to a limited extent for many years. The use of lead coatings as a substitute for more critical metals is increasing and may assume considerable proportions.

Concentrated Protecto Lead Solution, which has been sold by the Hanson-Van Winkle-Munning Company for many years, is now substantially improved by recent changes in the formula. To prepare a working solution, simply add three parts of water to one part of concentrate. The resulting solution is for general purposes, plating at low to medium current densities. The plating range is from 5 to 15 amperes per square foot.

Another modern electrolyte is the B-H Lead Solution, which is not concentrated but is used for lead plating as prepared. It is designed especially for lead plating bearing surfaces, and is being used by large aircraft motor manufacturers. This solution produces deposits with the proper micro-structure for subsequent indium plating and heat treatment.

RIVET SET

AN OVERSIZED rivet set 2½ inches in diameter that is said to eliminate the danger of damaging thin skins is being



Oversized, polished rivet set

manufactured by the Aero Tool Company. Even in the hands of unskilled labor, the extra large face and light weight of this set reduce rejects and speed flush riveting operations. A mirror-like, ultra-smooth finish on the crown surface protects thin skins from dents and abrasions while riveting.

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 PLANNING Now is a compilation of interviews with key manufacturing executives and government officials throughout industrial America. It presents a summary of American industry's blueprints for the future. *New York Journal of Commerce, 63 Park Row, New York, New York.—25 cents.*

A.S.T.M. STANDARDS ON PLASTICS is a 445-page compilation presenting 85 specifications, tests, and definitions. These cover the general field of present-day plastics and should be of interest to all concerned with the manufacture or use of such materials. *American Society for Testing Materials, 260 South Broad Street, Philadelphia 2, Pennsylvania.—$2.00.*

BETTER CROPS is an eight-page folder describing the uses of Hormo-Fert—a fertilizer with plant hormones added—and the results which have been obtained under test conditions. *Weil's Fertilizer Works, Goldsboro, North Carolina.—Gratis.*

MAINTENANCE ARC WELDING is a 234-page illustrated book designed as a guide and reference covering one of the most common and useful fields to which modern arc welding is applied. The information will be found particularly useful in keeping machinery and plants in operation despite shortages of material and equipment. *The James F. Lincoln Arc Welding Foundation, P. O. Box 5728, Cleveland, Ohio.—50 cents.*

RESEARCH IN STEATITE PORCELAINS is a 48-page engineering report covering a study of the firing behavior of the clino-enstatite field employing talc minerals, magnesia, and silica, plus a study of the talc minerals in steatite bodies. *Engineering Experiment Station, Ohio State University, Columbus 10, Ohio.—50 cents.*

WAGE INCENTIVES IN WARTIME is a 48-page discussion of this method of increasing production without extra manpower. The text is planned as a guide to management, and covers the whole subject clearly yet concisely. *Consolidated Management Consultants, 521 Fifth Avenue, New York 17, New York.—Gratis.*

TOP PERFORMANCE IN STEEL CUTTING is a 16-page vest-pocket sized guide to the characteristics of different grades of carbides designed for steel cutting, selection of proper rake and relief angles, size of radius, and so on. Attention is also given to machine requirements, speeds and feeds, design and grinding of chip breakers, and the problem of coolants. Trouble-shooting suggestions are included. Manual GT-166. *Carboloy Company, Inc., Detroit 32, Michigan.—Gratis.*

SPECIAL TOOL HANDBOOK is a 60-page, flexible-bound catalog which includes illustrations of high-speed-steel cutting tools, together with specifications. It is designed to fill a need for a basis upon which to select special tools for special requirements. *U. S. Tool and Manufacturing Company, 6906 Kingsley, Dearborn, Michigan.—Gratis.*

SEVENTY-FIFTH PENN METAL YEAR is a 28-page anniversary booklet tracing the history of one metal producing organization through its formative years up to the present day. *Penn Metal Corporation of Pennsylvania, Oregon Avenue and Swanson Street, Philadelphia, Pennsylvania.—Gratis.*

PNEUMIX in action is a 24-page pamphlet describing a number of types of air-motored agitators and their uses in industry. Two features claimed for these agitators are the elimination of fire and explosion hazards and the variable speeds obtainable through air control. *Eclipse Air Brush Company, Inc., 400 Park Avenue, Newark 7, New Jersey.—Gratis.*

CLEANERS FOR METALS is a bulletin dealing with the selection and use of cleaners made from water solutions for the removal of oils, machining chips, abrasives, and various dirts incident to metal producing and fabricating. A total of 19 special cleaners is described. Also included is a discussion of metal-cleaning processes in general. Bulletin C-105. *Hanson-Van Winkle-Munning Company, Matawan, New Jersey.—Gratis.*

MATERIAL HANDLING EQUIPMENT is a single sheet which describes and illustrates a number of lift trucks, elevating platforms, hoisting trucks, and similar equipment for various types of material handling. *Lyon-Raymond Corporation, 1402 Madison Street, Greene, New York.—Gratis.*

WOMEN A.W.O.L. is a 32-page pocket sized booklet which discusses the problem of women absenteeism in industry, and of the incentives which can be offered to reduce this important factor to a minimum. *National Foremen's Institute, Inc., Deep River, Connecticut. Sample copy gratis, quantity rates on application.*

THE IMPROVEMENT OF METALS BY FORGING is a 36-page reference data book which, through the use of charts, photographs, and detailed drawings, presents factual working information drawn from years of practical experience. Content covers types of forgings, forging design principles and processes, the metallurgy of forging, and metal specifications and physical properties. *The Steel Improvement and Forge Company, 734 Union Commerce Building, Cleveland, Ohio.—Gratis. Request this booklet on your business letterhead.*

Our Book Corner

THE BOOK DEPARTMENT of Scientific American is conducted, with the co-operation of the Editors, to make available for you a comprehensive book service. Each month the Editors select and review in these columns new books in a wide range of scientific and technical fields. In addition, they are ready at all times to advise you regarding the best available books on any subject. You are invited to use this service freely. Tell our Book Department what kind of books you want and you will be furnished with the names of available books, including prices. When inquiring about books, please be specific; remember that we can be of the greatest help only when you tell us just what you are looking for. Books listed in these columns may be ordered from our Book Department. Add 25 cents per book for mailing outside U. S.

TO MAKE CERTAIN that books ordered by or for men in the Army, located in the United States, or men in the Navy, located anywhere, will be delivered, insurance fees should be sent with orders, as follows: To $5 in value, 5¢ additional; from $5 to $25, 10¢; from $25 to $50, 15¢.

HE'S IN THE SUB-BUSTERS NOW

By A. D. Rathbone, IV

TRAINING THE LADS who are hunting down and killing the rattlesnakes of the sea is the theme running through this human interest story of one phase of our war effort. The various PT-boats, the Patrol Craft, the aircraft service, and the newer Destroyer Escort Service, all are treated as a part of the over-all program of sub-busting. Emphasis is on the spectacular and dramatic—the reader being figuratively taken for rides in the various craft—but enough data are presented to give substance to what otherwise might be just another war story. Recommended to boys about to enter the service and to parents of boys now in action. (224 pages, 7 by 9½ inches, numerous excellent photographs.)—$2.60 postpaid. —*A.P.P.*

GENERAL CHEMISTRY

By L. E. Young and C. W. Porter

TEXT books, even more than other books, profit by revision after they have been applied to their intended purpose for a time. Thus this revised edition, appearing three years after the first appearance of the book, brings a swift-moving subject up to date. The text is well written for a first course in chemistry in the class room and should interest the well-informed reader who seeks a deeper knowledge of chemistry but lacks the opportunity for class work. (527 pages, 6 by 9 inches, illustrated.) —$5.10 postpaid.—*D. H. K.*

BELOVED SCIENTIST

Elihu Thomson, A Guiding Spirit of the Electrical Age

By David O. Woodbury

RICHLY spiced with anecdotes of the great man's life from early childhood to the day of his death, this fat volume tells the story not only of Thomson's work but also of the contemporaneous development of the electrical industry. Thus it serves the twofold purpose of recording for posterity the human side of one of the outstanding geniuses of electricity and the factual side of the developments for which he and other great men were responsible. Into the pages of this book step such men as Edison, Westinghouse, Steinmetz, Crooks, Marconi, and others, to flash briefly across the canvas which is devoted mainly to a portrayal of Elihu Thomson. Read it for its human interest and be rewarded with a warm portrait of a gentle, kindly soul; read it for knowledge of the embryonic electrical industry and be equally rewarded with well-documented data. (358 pages, 6 by 9½ inches, a number of photographs.)—$3.60 postpaid.—*A.P.P.*

THE SOURCES OF LIFE

By Dr. Serge Voronoff

REJUVENATION by means of transplanted monkey glands was supposedly about extinguished as a scientific procedure a decade or two ago but this book looks like a last-hour attempt to rejuvenate it. It retells essentially the same old story, which neither biological science nor medicine has as yet given the accolade. (240 pages, 6 by 9¼ inches, 47 illustrations.)—$3.60 postpaid.—*A.G.I.*

DIESEL LOCOMOTIVES IN MECHANICAL EQUIPMENT

By John Draney

A SOLID text dealing in the utmost detail with the Diesel engine in all its developments, with particular reference to its adaptation and use in railway transportation. (472 pages, 6 by 8½ inches, a large number of drawings and a few photographs.)—$4.10 postpaid.—*A.P.P.*

AIRCRAFT NAVIGATION

By Stewart, Nichols, Walling, and Hill

THIS book authoritatively covers elementary air navigation and is British in origin. Under "theory" it deals compactly with star identification; form of the earth; maps and charts; map reading; scales and time scales; drift, bearing, back bearing and wind direction; triangles of velocity; magnetism and compass; altimeter; airspeed indicators; meteorology; clouds;

also, under "practice," with Mercator's chart; circular slide rule; magnetic compass; fixes; wind effects; radius of action; problem of continuing heading or returning; fixing position by radio bearings; interception; prepared log. It contains many problems and the answers to them. (146 pages, 5½ by 8 inches, 24 figures.)—$2.10 postpaid.—*A.G.I.*

A LABORATORY MANUAL OF PLASTICS AND SYNTHETIC RESINS

By G. F. D'Alelio

PRACTICALLY all of the well-known resins and plastics which can be prepared readily, even in a small laboratory, have been included in this manual designed for college students who have already studied organic chemistry. Although the text was prepared for classroom use, it will furnish valuable information to anyone possessing the necessary background for a more extensive and specific study of plastics. (134 pages, 8 by 10½ inches, well illustrated, paper covers and spiral binding.)—$2.10 postpaid.—*A.P.P.*

SUCCESSFUL SOLDERING

By Louie S. Taylor

BY TELLING the "why" of soldering, the author furnishes the background for teaching the proper "how" of an extensively used process which all too often is performed incorrectly. After the routine of soldering is carefully covered, special problems are dealt with such as soldering black iron, stainless steel, aluminum, lead, and so on. (76 pages, 5 by 7½ inches, 24 large photographic plates and two drawings.)—$1.10 postpaid.—*A.P.P.*

MINERALS

By Herbert S. Zim and Elizabeth K. Cooper

HOW TO collect, identify, and use minerals is the subject of this hobby book written, as the authors tell us, "for the fun of it." The approach is very elementary; even a youngster could understand the language. The treatment is entirely practical; the text tells how to proceed with identifying tests. (368 pages, 5¼ by 8 inches, illustrated.)—$3.10 postpaid —*A.G.I.*

ELECTRON-OPTICS

By Paul Hatschek

SIMPLIFIED fundamentals of electronics, translated from a book that was originally written in 1935 and 1936, yet just as good today as when the author first planned the volume. Obviously, then, this text does not emphasize present-day applications of electronics, but it does give the basic fundamentals in such form as to be readily graspable by the average person. While main emphasis is upon those electronic principles which are particularly applicable to the television field, they are interpreted in broad enough fashion to serve a much wider field. A single short chapter surveys recent electronic applications. (160 pages, 6 by 9 inches, 125 illustrations.)—$3.10 postpaid.—*A.P.P.*

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"

Of the three ways to make optical flats, briefly outlined by Porter in "Amateur Telescope Making," page 57, the first, or three-disk method, is described at greater length by Selby in "Amateur Telescope Making—Advanced;" the second, or Ritchey, method using concave mirror and knife-edge accessories is described by Pierce and Ritchey in "A.T.M.," page 241; but the third, or borrow-a-master-flat method, is not covered in either book.

"Why keep this third method in the optical doghouse?" a few have asked, "What do you hold against it?" The method is excellent—provided the user can borrow the necessary master flat. John W. Erdman, 50 Howland Ave., North Hackensack, N. J., an amateur astronomer and telescope maker who has worked several years as a professional precision optician, now offers the rest of the fraternity the full recipe for method 3. He writes:

First, procure a flat as your testing piece—by the "beg, borrow, or steal" method if necessary. Even one which may not be absolutely flat will be of great help, but in such case some other final test would be necessary.

Use Pyrex; it is more dependable for maintaining surface than plate glass, is less likely to spring out of shape if the glass is to be blocked on either wood or metal, and is less affected by heat generated from polishing.

Choose the face having the lesser diameter for the optical flat side. The taper then will tend to prevent, rather than facilitate, accidentally dropping the disk when the hands are wet. Hence, grind the larger face first. Proceed on that side with the usual grades of emery, grinding against any suitable flat surface. A grinding tool slightly larger than the disk, roughly one tenth larger, may be used to advantage, as will be shown later. A tool made with facets is a great help in eliminating zones. Those having a lathe can make a good grinder by cutting a series of concentric rings in a metal tool.

The back (larger) face may be polished quickly and needs no figuring. All we require is clean polish and reasonable flatness. A wavy or irregular surface might, however, introduce incorrect interpretations of the interference fringes on the other side.

Now for the all-important surface on the smaller side.

Some form of monochromatic light must be provided. A fluorescent lamp may serve in the early stages of polishing, but is not suitable for the final testing.

The grinding of the second face proceeds as before, except that with each grind of emery the surface must be brought closer to flatness, testing with a straightedge and frequently inverting the tool, whether it be glass or metal, to maintain this flatness. If a straightedge is not available, the borrowed test flat will serve if moistened (for this there is nothing better than the tongue) and pressed into close contact with the surface. The moisture spreading between the glasses will show even minute deviations. The straightedge can be checked by carefully placing it on the test flat.

In the final stage of grinding, great care is necessary in bringing the surface as nearly flat as possible. Here moisture from the breath is sufficient in the test against the master flat. Better still is testing the fine grind by interference. If this grind is brought to a satiny, glossy finish, fringes may be seen by placing the two glasses in contact and viewing them at 18" to 24" from a very low and slanting angle. A fluorescent light will not serve for this test. While the view from this angle is not exactly correct, it is close enough at this stage. Move the test glass off center and study the fringes clear to the edge. Often they appear quite straight over most of the ground glass, but break off toward the edge. Continue grinding until this condition is eliminated.

Close attention must be paid to the stroke in grinding, so that if small errors are to be corrected, the least amount of effort will be required. The same type of strokes are used as in producing a spherical surface. A flat must be considered, both in grinding and in polishing, as a spherical surface. If it appears concave, it is treated exactly as a concave surface which is too deep. If it appears convex, it is treated as a convex surface which is too steep.

The work may have to be turned from bottom to top several times, before completing the grind. Never, however, attempt to polish until the interference fringes show that the surface is quite flat, for it is much simpler to grind out imperfections than to polish them out. Watch particularly for concave zones near the center, and for turned down edge. These cannot be tolerated. One wave regular curvature is acceptable; ½ wave, or 1 ring, is still better. If the rougher grinds were kept reasonably flat, it should not be difficult to bring the fine grind this close. With the borrowed master flat as guide, making small changes in stroke, this can be attained without too much difficulty. Again it must be stressed, do not polish until the fringes show not more than two rings of regular curvature.

The first job connected with polishing is making a lap. I sometimes have found advantage in using a lap of slightly larger diameter than the disk (approximately ½" larger for 6" work). If a slightly oversized grinding tool is used, it will do nicely in making the lap. One advantage in polished flat work is that many types of materials, only reasonably flat, will serve as backing for the lap. Thick plate glass, properly supported, will do. Often, in making a flat, a full-sized lap can be used in polishing on top, and the oversized lap on the bottom when the disk is to be inverted. Here a great deal is left to the worker and to the intricacies of each particular job.

Use a pitch somewhat on the hard side, but not too hard. Good work can be produced on pitch of varying hardness, but nothing but new difficulties will arise from using pitch harder than necessary. Keeping full contact with the glass is absolutely necessary. Pitch that is too hard often makes this difficult.

Build a small dam around the warm tool (ordinary masking tape serves nicely for this) and pour on a thin layer of pitch. A little less than ¼" is about right for 6" work. As soon as possible, remove the dam with short, quick pulls. Raised edges of the pitch may be chopped off with a razor blade.

When the pitch begins to harden, yet is still quite warm, smear on rouge having a consistency on the pasty side, and carefully rub the lap to shape with the fine-ground flat. Rub lightly at first, and add pressure as the lap takes shape, using short strokes and small circles. Do not allow too much heat to get into the glass; remove it from time to time to cool. Continue this until the pitch is fairly cool, having assured yourself that the lap has come to full contact all over.

With a little warmth still left in the lap, clean off all the rouge and scrape small channels into the pitch with the corner of a razor blade. They should be cut clean across the lap with one quick stroke of the hand, and about 1/32" deep. Five or six strokes in one direction are crossed with as many in one or two directions, until a reasonably regular criss-cross pattern is achieved. It is not, however, necessary to space these scratches carefully, but leave no one zone untouched.

New contact must now be made with the lap, until an even, steady pull with the stroke is felt.

When the lap is fully cool, actual polishing may begin. Within a few minutes, the worker can note whether his flat has begun to polish with reasonable evenness. A spotty condition in the polish will indicate that the lap is out of contact, and re-heating is necessary. The easiest method to reheat a lap is to invert it in a pan of warm water for a minute or two. Cold pressing between spells is not recommended with this type of lap. Just warm it a little before the start.

If an oversized lap is being used, it should remain on the bottom, even if the first test shows that the work is concave. Simply proceed with short strokes for a polishing spell, and study with the test piece what changes occur. If this first test indicates that the work is convex, proceed with longer strokes. These strokes must vary with your own judgment, while watching the response with the borrowed flat. There is no need for waiting long to test at this stage, since small variations are not yet important. It is well, however, to keep in mind that heat generated from polishing will give you a reading on the convex side of the true condition. For example, if the first reading should indicate absolute flatness, the work will nearly always be at least one ring concave. If it appeared at first a little concave, it will ultimately cool off even more so. At this point we are concerned mostly with an even polish, keeping the surface as flat as possible and free from zones. If a machine is used, a slow, steady stroke should be selected.

The scratches on the lap should never be permitted to close in entirely but should be removed as soon as the worker sees that they are becoming filled. They are purposely made shallow, so that they may be changed or modified to meet the irregularities or any conditions which may develop in the surface of the flat. For example, if a small hole should begin to appear near the center, new scratches can be cut in the lap at the corresponding spot. As this hole begins to disappear, these scratches need not be renewed, and will soon flow back into the lap. If the edge of the glass appears to be turned up, the scratches may be deepened more in the central section of the lap and temporarily not renewed at the edge. All normal deviations may be dealt with in this manner. However, no large zone should ever be left without any scratches at all, else serious irregularities may develop. Generally, when certain corrective scratches are made, enough former ones remain in other zones to suffice. In this fashion I have produced several flats, free from all irregularities, with a single oversized lap used entirely on the bottom.

Do not be afraid that the oversized lap will develop a turned edge. Reasonable care with the stroke will prevent this. In fact, an undersized lap will more quickly result in a turned-up edge. In mirror making, where infinitesimal deviations of radius have no importance, a turned-up edge is easily dealt with; while in flat making, the radius being infinity and necessarily kept so, treating a turned-up edge will often produce an undesired radius in the work. Frequently a finished flat, quite satisfactory as far as edge condition is concerned, will show from the fringe reading a faint blur in the outer 1/64". Since this amount will be taken off with a bevel, it should not concern the worker, as this sharp edge must be removed at any rate.

When an equi-sized lap is used throughout, the worker will naturally polish face up or face down, as the curve of his surface demands. Do not always, when it is found that a fairly long stroke has changed the reading from concave to convex, or vice versa, be too eager to invert the work, but try first a shorter stroke.

As in grinding, close attention must be paid to the stroke used, in order that small changes can readily be dealt with by the necessary alteration in stroke.

As each job has new characteristics, these must be dealt with through the ingenuity of the worker. Sometimes when a hole persists in the central zone, and continual renewal of the scratches fails to correct it, a hole may be cut in the center of the lap, beginning with a small one and, if necessary, enlarging it. If a turned edge should persist, cut small scallops around the edge of the lap.

By following these methods the worker should have no difficulty in making a good flat; especially through bringing the fine grind as nearly flat as possible and keeping it that way throughout.

It is well to move slowly until you are sure of yourself. Usually, time is saved in the end.

In the final stages allow from 20 to 40 minutes for cooling—depending upon the length of the polishing spell—for a good test.

A flat can be called really good if the fringes, when separated about 1½", are straight clear to the edge. Rotate the flat and view the fringes in several directions; a minute cylindrical condition will not necessarily reveal itself from a single axis.

If the flat is to be used solely as a testing piece or master flat, polishing need continue only until naked-eye evidence of the final grinding is removed. Small pits will in no way lessen its value.

In making the plane side of a lens, the same procedure may be followed. Usually one ring of regular curvature is acceptable, hence such a surface is a great deal easier to produce than the master flat. Turned edges of small degree may be ignored, since the centering of the lens will remove them. Prism faces are naturally more convenient to polish on top, and an oversized lap should always be used. The lap should have a circumference equal to or slightly larger than the longest dimension of the prism face. When a number of prisms or lenses are set, or blocked, into plaster in circular form, a lap of the same size may be used, and the work may be treated exactly as if it were a solid surface.

WORK-LOVING beavers are not extinct in Beaver County, Pa., about 25 miles north-west of Pittsburgh. "The Beaver County Amateur Astronomers' Association" has just been organized there, William A. Lintz, 440 Navigation St., Beaver, Pa., being the secretary. In this organization are 13 members, a way of showing that astronomers snap their fingers at superstition. N. J. Schell, of off-axis (unobstructed) and criss-cross off-axis telescope fame, also Roelof Weertman whose 12½" turret telescope has been described in this department, are members of this new group. Paul McConnell, of Beaver, is its president and Keith Shields of Fair Oaks its vice-president.

Aviation

(*Continued from page* 168)

reaction is not practicable for commercial work, the day will come when this efficiency will be increased and the new type of power plant will be used not only for auxiliary purposes but for commercial operation as well. Some of the possibilities are very tempting. Almost any form of fuel can be used; the air screw with its complexity and noise would disappear; an efficient power plant would be attained at the very greatest altitude; and since the air screw can be dispensed with, the aircraft would be low and compact. The power plant can be housed entirely within the wing. Noise would be to the rear of the pilot, vibration would be eliminated.

All this may possibly give an unduly optimistic view of the situation. No one can predict the future nor is the above anything but a brief introduction to the subject. Enough has been said, however, to indicate the importance and great possibilities of jet-propulsion flight.

THE BOSSI HELICOPTER

Has Two Rotors

Turning in Same Direction

A HELICOPTER, now in process of test by Higgins Industries, was designed by Enea Bossi, an aviation man of long and distinguished career, who is shown in one of our photographs chatting with his son Charles. Mr. Bossi has to his credit the first flying boat to be built wholly of stainless steel.

The helicopter is equipped with a 175-horsepower Warner engine cooled by a special blower. Its gross weight is 2500 pounds. The diameter of the rotor is 33 feet, and its speed is 315 revolutions per minute. The rotor is equipped with four blades, one pair of blades rotating above another pair, but both pairs rotating in the same direction. Under these conditions a means for counteracting torque must be provided. Therefore there is a variable-pitch propeller at the rear of the fuselage. The tail propeller not only counteracts torque; it also acts as a rudder suitably controlled by foot pedals.

A helicopter design is far from being a matter of aerodynamics. Mechanical problems, such as the transmission, loom large. Thus the motor is connected to the transmission by a special coupling which gives the effect of a universal joint and the transmission box comprises a clutch, a free-wheeling device (to come into play if the engine fails and the blades have to auto-rotate), bevel gears leading to the anti-torque propeller, and planetary gearing for reduction of speed from engine to rotor. Above the transmission box is a brake to keep the rotor from turning when the machine is on the ground in windy weather. The air intake for cooling the engine is through the scoop which can be noted in the photograph.

The rotor is mounted on a universal joint which permits it to be inclined in any direction, and the direction in which the rotor is inclined is also the direction in which the airplane is propelled. Because of this universal mounting of the rotor, the fuselage remains horizontal under all flight conditions—take-off, forward flight, and landing.

INGENUITY

Demonstrated by Propeller

Technicians Abroad

WHEN a group of Hamilton Standard technicians were landed in far-off Eritrea, they found themselves equipped with only a few service manuals and a scattering of pocket tools. An entire shipment of heavy servicing equipment had been sunk en route. With this meager start, they devised the intricate mechanisms needed for carrying on their assigned duties, proving the resourcefulness of the technicians who keep 'em flying.

Enea Bossi (right), his son, and helicopter with four rotor blades

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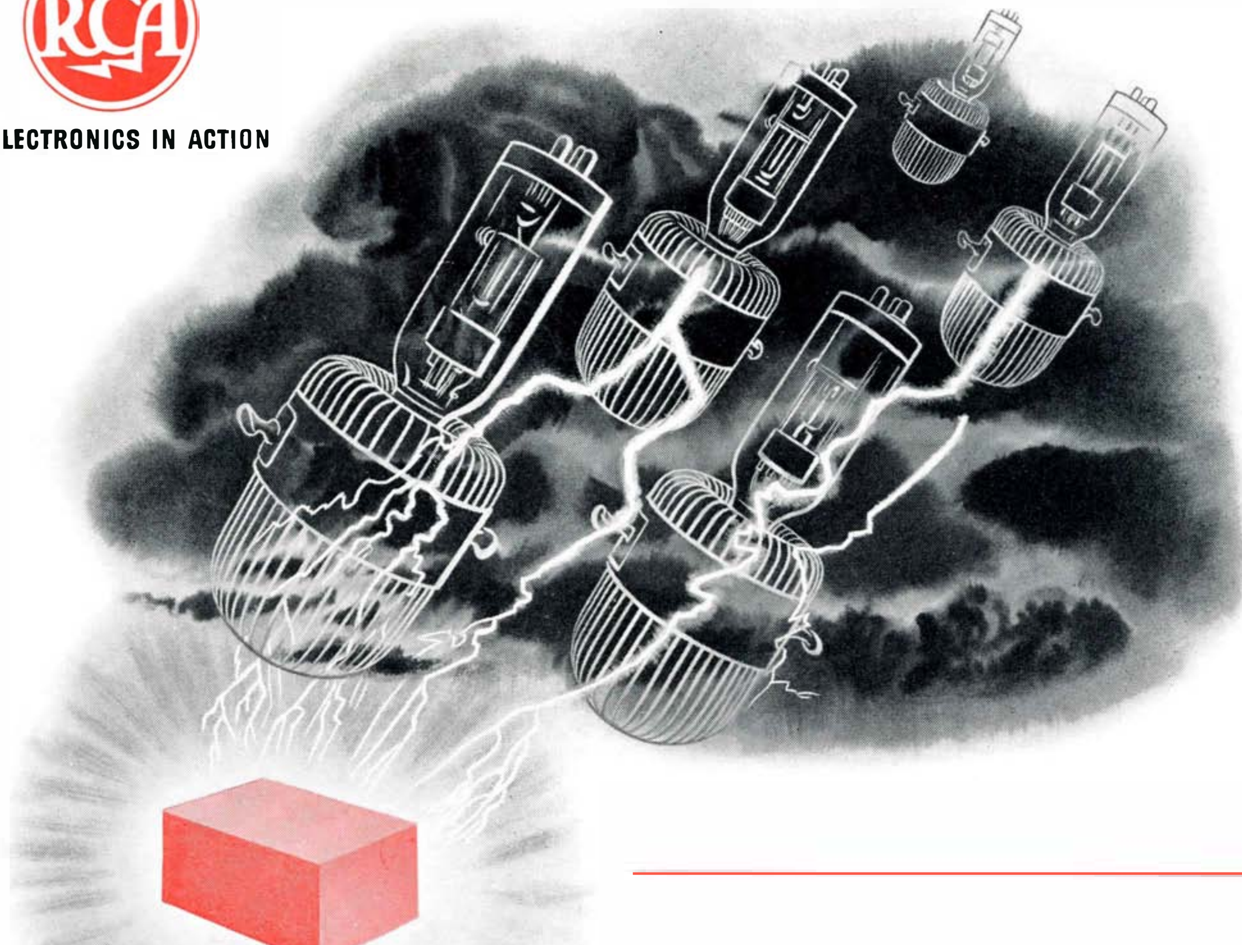
ELECTRONICS IN ACTION



Homogenized Heat

BOIL a potato; broil a steak; bake a loaf of bread—in every case the heat flows from the outside to the inside. Result: the outside is always "well done" while the inside is still "rare." In the kitchen this may be a desirable situation, but in the plastics industry a similar condition made trouble—until high-frequency heat, generated by electron tubes, came into the picture.

For in molding thermosetting plastics, a briquet, or preform, of the material must be heated *uniformly* to soften it for molding. Too much heat causes the outside of the preform to "set" prematurely; too little heat leaves a hard lump in the center.

By the application of high-power radio-waves to this heating job, heat can be generated *uniformly* throughout the plastic preform. The entire mass softens at once—without a hard external "crust." Because the heat is "born" inside of the plastic material, the temperature can be increased rapidly, valuable time is saved, better plastic products result. This is homogenized heat! A new tool of industry!

This new heating method can be applied to many substances—wood, glue, paper, textiles, rubber, foods, tobacco, leather. It is clean—quiet—efficient—extremely fast—and can be controlled with extreme accuracy.

You may have a problem where this new application of electron tubes would prove useful—or even revolutionary. If so, write us about it. *Remember, the Magic Brain of all electronic equipment is a tube—and the fountain-head of modern tube development is RCA.* Write today. Address: RCA, Dept. 68-7N, Camden, New Jersey.

★ BUY MORE WAR BONDS ★

Write for this 44-page booklet—"RCA ELECTRONICS IN INDUSTRY"—which suggests important electronic applications that may help you. Non-technical, thoroughly illustrated in color. Your copy will be sent promptly on request. Address Radio Corporation of America, Dept. 68-7N, Camden, New Jersey. (Please use business letterhead.)

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