Scientific American

SEPTEMBER
1943

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REPORTING THE PROGRESS OF SCIENCE AND INDUSTRY

"Machine Gunners" on the Production Front . . . See Page 98

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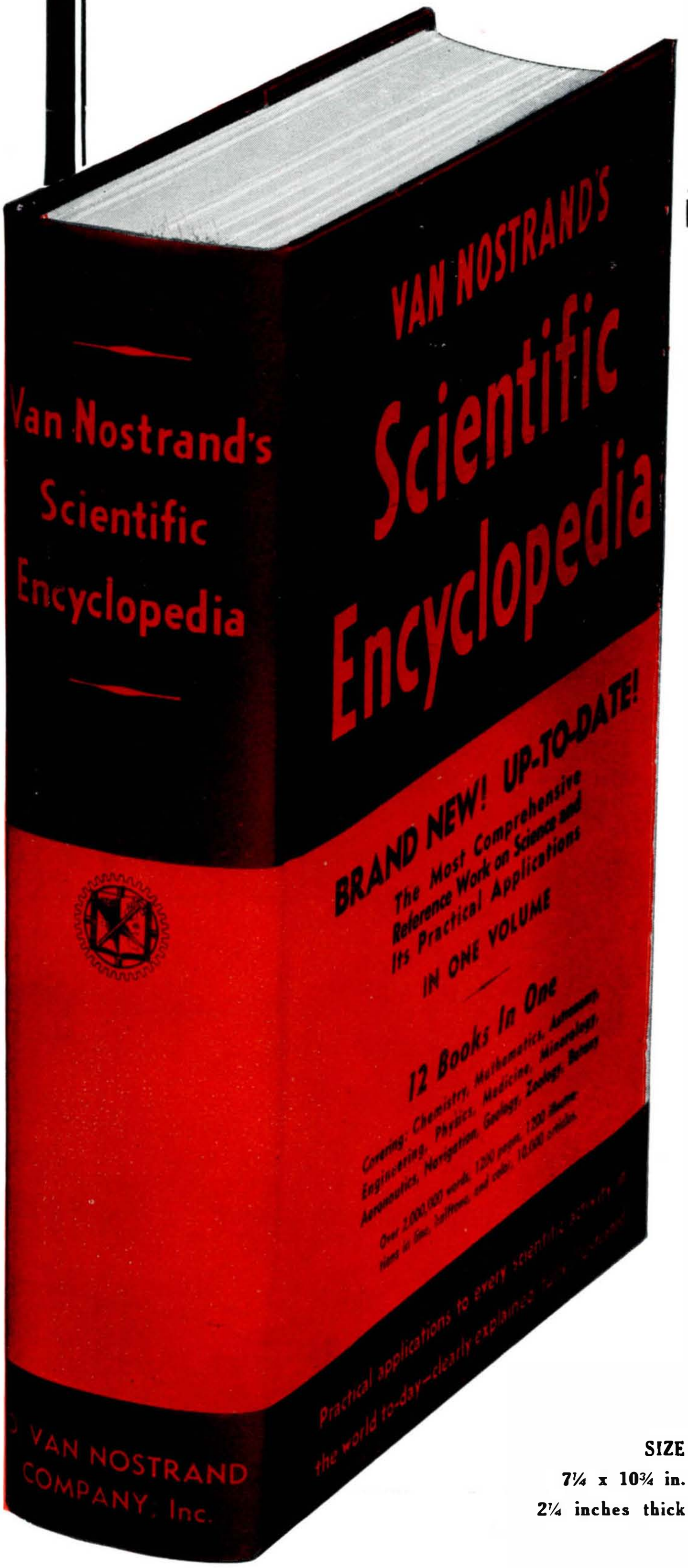

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Scientific American

Founded 1845

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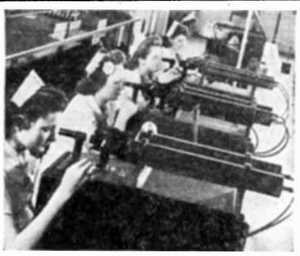

THE "machine guns" shown in the illustration on our front cover are actually collimators used in checking binoculars for sharpness and definition of image as well as for testing optical alinement. Precipitrons — electric air cleaners— protect the equipment from dust, lint, and other air-borne dirt particles. The girl inspectors even shun face powder lest a flake obstruct part of an optical system. Photo by Westinghouse.

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Previews of the Industrial Horizon

A. P. Peck

HEAT WITHOUT HEAT

INDICATIVE of the many ways in which the science of electronics is invading industry is the article on electrostatic and electromagnetic heating on page 103. Starting as a laboratory stunt only a few years ago, electronic heating is now speeding many processes involving both metals and non-metallic materials. Despite its high cost, compared with other heating methods, electronic heating is finding more and more applications where its advantages outweigh its cost. When heat must be closely confined to a limited area, when parts to be heated are relatively inaccessible, and in many other instances, electronic heating comes to the fore. It will blossom to an even greater extent when consumer-goods manufacture once more gets underway and the lessons that have been learned in war-time production are turned to pursuits of peace.

WHERE MASS IS IN MOTION

OPTIMISTIC indeed is the post-war outlook for aluminum and magnesium and alloys employing these two light metals. With a projected production of over a million tons of aluminum annually by the end of 1943, and correspondingly large amounts of magnesium, there will be productive capacity available that will bring aluminum into poundage competition with copper, and not too far behind iron and steel, when all phases of the situation are considered. Watch uses of aluminum and magnesium zoom, particularly for vehicles where physical masses have to be moved by horsepower, as well as in building construction and the electrical industry. Peace-time applications of the light metals will even surpass many of the present optimistic predictions.

STEEL IS NOT ASLEEP

REGARDLESS of the advantages that light metals hold in many applications, let there be no thought that they are going to capture markets from older materials without a struggle. Steel, for example, is just as alive to post-war possibilities as the light-metal industry and is busy planning for the future. Alloy steels are being developed today far beyond the wildest dreams of only a few years ago. These alloys, tailored to measure for special jobs, will find uses from which they cannot be dislodged. The final balance in the metals field (as far as it can be reached this side of Utopia), will find each metal in its best place, with the ultimate consumer as the greatest beneficiary of research.

A SKIN-DEEP METAL

ANOTHER phase of the metals situation, which will have far-reaching effects in the machine-tool industry as well as in other lines where hard surfaces are needed for one reason or another, concerns the rapidly expanding uses of industrial chromium plating. See page 112 for details. Boring and milling tools, cylinders and pistons, bearings and dies are all feeling the impact of the development of the hard, smooth surface made possible by a plating of chromium. The results so far indicate possibilities for the future that will embrace many metal fields where plating has never before been used.

CHEMICAL RUBBER

NO MATTER which side of the picture is looked at, the tremendous development of the synthetic rubbers is going to have a lot to do with consumer goods in post-war days. An idea of the vast possibilities of man-made rubbers may be gleaned from the article starting on page 115. That the work which has been done so far, and which will result in an installed capacity in excess of prewar natural rubber consumption, will have its effect on natural rubber production in the future is a fact that cannot be overlooked. The properties of some of the synthetics are such that they cannot only replace natural rubber in many uses but can do a better job in certain respects.

NATURAL RUBBER

SOME POST-WAR planners in the rubber field are advocating a return to the importation of natural rubber from its former sources and the development of new natural sources in the Western Hemisphere. Arguments are usually based on matters involving wages and standards of living in the areas of rubber production. This, of course, brings into the picture comparative costs of synthetic and natural rubbers and poses questions which only time can answer. Incidentally, rubber from guayule, golden-rod, and so on appears slated to remain in the experimental stage for some time to come. Synthetic rubber sources have been developed more rapidly than nature can produce rubber in these plants; hence synthetic has become *the* rubber of (at least) the duration.

TRANSOCEANIC FLIGHT

IF AND WHEN the Armstrong Seadromes (see page 118) provide stepping stones across the Atlantic, some ideas about transoceanic flight will have to be revised. The flying boats of the present are designed for long flights with large loads of fuel; the planes which use the Seadromes will be landplanes and need not be burdened with as much weight in gasoline. Greater pay loads will be possible when the oceanic stepping stones are available, and the air transport industry will be able to compete on a more stable basis with other forms of transportation.

In the same vein there must be considered the possibilities of glider trains for transoceanic freight and express. The epic flight of a towed glider across the Atlantic, announced early in July, has already blazed another aerial trail. Coupled with recently developed methods of picking up gliders from the ground while the towing plane is in flight, this aerial transportation system holds possibilities limited only by the resourcefulness of engineers in the aircraft industry.

MORE NEWS ABOUT PLASTICS

NYLON has gone all-out for war, as the ladies of the nation know only too well. All of this synthetic material now goes into parachutes, tire cords, and other military requirements. As with many other products, however, research continues apace and now it appears that the basic nylon will find unusual applications in the plastics field after the war.

With the highest softening point and the greatest toughness of any of the thermoplastics, nylon plastic promises to overcome many of the disadvantages of thermosetting plastics while retaining their advantages. The previous upper limit at which thermoplastic materials will soften has been about 280 degrees, Fahrenheit; nylon will not soften until heated to 450 degrees.

Other properties of nylon plastic that will be found useful in post-war design include extreme toughness even in thin

(Please turn to page 135)

50 Years Ago in . . .

SCIENTIFIC AMERICAN

Condensed from Issues of September, 1893

ALUMINUM—"A new process for obtaining aluminum from its oxide includes chemical combinations heretofore supposed to be impossible. . . . The discoverer of this process and his Duluth associates say they can produce pure aluminum at a price considerably below that of any of the electrical processes, and cheaper, bulk for bulk, than copper. The native clay is useless. In fact, the only available mineral for the purpose is bauxite, which is an impure oxide of aluminum."

GAS POWER—"For a given tank capacity and with carbonic acid and air stored at the same pressure, the (liquefied) carbonic acid is capable of developing four to five times more power than compressed air."

EARLIEST MAN—"Scientific men are agreed that the human race did in some way arise from some inferior animal form—not necessarily monkeys. The transition may not have been gradual, but abrupt—evolution per saltum. We do not find the 'missing link'; it is still missing; it may be forever missing."

CORINTH CANAL—"The Corinth ship canal, connecting the Gulf of Lepanto with the Aegean Sea, was formally opened on July 29. . . . The canal is three and nine-tenths miles long and the minimum depth is 25 feet, while the average breadth is 100 feet. A bridge crosses the canal about a mile from the west end and is 230 feet above the water level, so that vessels can pass freely."

DUST ENGINE—"A novel motive power engine has been invented, based upon the fact that very finely divided carbon, floating in the air, readily explodes, and to adapt this to the generation of motive power the inventor proposes to grind coal to an impalpable powder, and, after introducing the dust floating in the air into the cylnder of an engine, explode it, the idea being to follow very much the same lines which are being so thoroughly developed in the use of gas in engine practice."

SAFE FARMING—"Secretary Morton reminds the croakers that only about 3 per cent of all the merchants escape failure, whereas hardly 3 per cent of the farmers fail. The statistics really show that agriculture is safer than banking, manufacturing, or railroading, taking all things into account."

TIN—"At the tin mines of the Maliwun Peninsula in the Mergui in the extreme south of Burma, there are two tin smelting houses, where during the smelting season seven hundredweight of tin can be smelted in a day by each furnace with four or five men."

WORLD'S FAIR—"Such a profusion of electric lights as one sees in the buildings and on the grounds of the World's Fair has probably never been viewed by mortal man before. . . . Arc and incandescent lamps are everywhere. The white buildings reflect the lights and make the scene as bright as day. On those nights when every lamp is burning, the electric fountains playing, and fireworks are shooting up from the lake, the scene is almost beyond description."

DECIMAL POINT—"In both France and Germany one-fourth (¼) reduced to a decimal is written as 0,25; in England it is written 0·25 (always with the period at the top of the line), and in the United States in this way, 0.25."

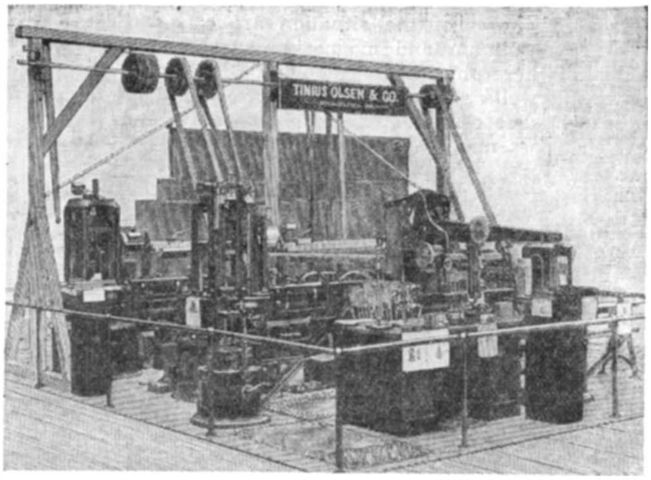
RIFLES—"Breech-loading rifles were invented in 1811, but did not come into general use for many years. It is estimated that over 12,000,000 are now in actual service in the European armies, while 3,000,000 are reserved in the arsenals for emergencies."

SWEET—"Sucrol is the name given to parapheneta1 carbamide, a harmless substance of deliciously sweet taste, produced by adding a solution of potassium cyanate to muriate of amidophenetol. . . . It has no influence on the circulation, respiration, or digestion, nor on the nervous system in general."

PLATING—"In no branch of the electroplaters' art has there been so much progress made in recent years as in that of copper plating. With improved solutions and methods, copper plating is becoming a more important industry every day."

POWER—"In Auburn, Me., Mr. Charles Dunn, one of the most progressive brick manufacturers in New England, has arranged an electric motor to do the work of horses in grinding. . . . Other New England manufacturers are adopting the use of electricity in their plants, and with such excellent results as to premise the opinion that it will soon become universal."

TESTING—"The exhibit of Tinius Olsen & Co. at the World's Fair includes a new autographic and automatic testing machine which registers up to 100,000 pounds; a new torsional testing machine which will test bars up to two inches in diameter and sixteen feet long; a cross section testing machine for cast iron; a wire and band iron testing machine, which was largely used in testing wire for the electrical department; a cement-testing machine, etc. Mr. Olsen has invented—and patented—a great number of improvements in testing machines and instruments. . . . The firm also make instruments for indicating the point of elastic limit, a duplex micrometer measuring instrument, etc."



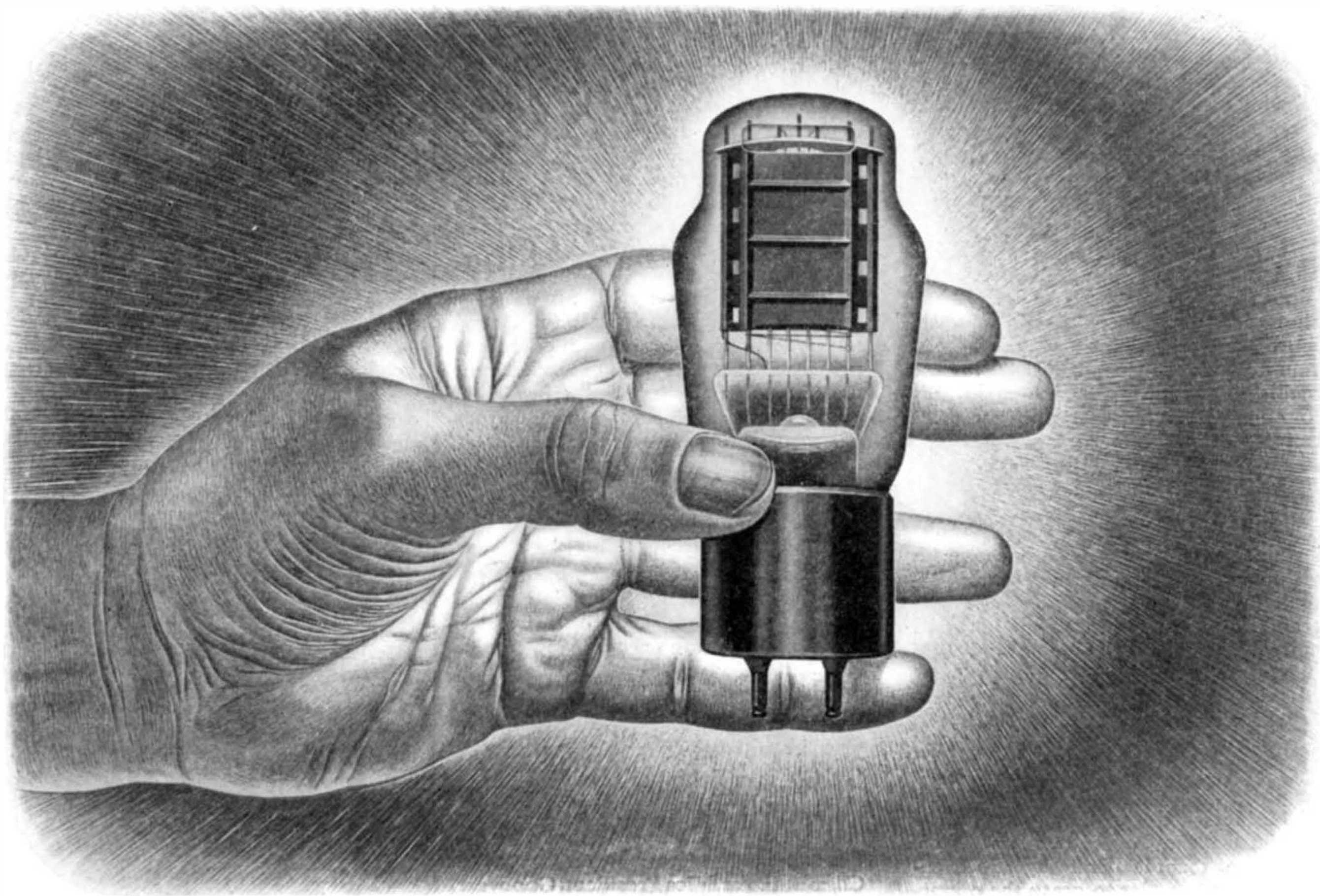
Olsen testing machines at the World's Fair

FLASHLIGHT—"Aluminum, if employed in the form of bronze powder, is equal to magnesium as a source of light in taking photographs by flashlight, and is much cheaper than the latter."

MANUFACTURING—"The United States is now the leading manufacturing country in the world. We have far outstripped all other nations in the magnitude of our industrial operations. . . . In the United States we have scarcely laid the foundation for our future greatness. In natural resources we are richer than all of Europe."

TIRES—"The requisites of a good rubber tire: The envelope must be strong enough to stand a pressure of sixty pounds to the square inch, and at the same time of such lightness as to allow the air in conjunction with it to act as a perfect cushion."

"IT OUGHT TO GET A WAR MEDAL"



THIS little tube *can't* help you smell. But it *can* help you talk, see and hear. Right now, it helps direct guns, planes, ships. It ought to get a war medal.

It has given birth to a new art called Electronics.

In 1912 in the Bell Laboratories, Dr. H. D. Arnold made the first effective high-vacuum tube for amplifying electric currents.

Vacuum tubes made possible the first transoceanic telephone talk by the Bell System in 1915.

Vacuum tubes are now used on practically all Long Distance circuits to reinforce the human voice.

That's why you can talk across the continent so easily.

Over 1,250,000 electronic tubes are in service in the Bell System. Bell Laboratories developed them, Western Electric made them.

But both Laboratories and Western Electric are busy now with war — turning out tubes and putting them to work in many a device to find and destroy the enemy on land, in the air, and under the sea.

After the war, this Bell System army of tubes will work in thousands of ways for peace.

BELL TELEPHONE SYSTEM

HELP THE WAR BY MAKING ONLY VITAL CALLS TO WAR-BUSY CENTERS. THAT'S MORE AND MORE ESSENTIAL EVERY DAY.

"Quotes . . ."

"INDUSTRY CALLED in science years ago to solve its technical problems. The constant succession of improved and new products, together with the extraordinary advances in mass production and lower consumer prices over a long period of time, marks the success of this idea." *David Sarnoff, President, Radio Corporation of America.*

" " "

"THE NEW projects which du Pont will be ready to launch when the war is over, together with increased outlets for existing products, are expected to give rise to an all-time high in peacetime employment by the company." Lammot du Pont, chairman of the board of the E. I. du Pont de Nemours & Co.

" " "

"IT SEEMS inevitable that the American people will want to continue at least standby operation of these [synthetic rubber] plants, just as they will want to retain air bases and battleships." *John L. Collyer, President, B. F. Goodrich Company.*

" " "

"IT WOULD BE helpful if the metallurgists would be less willing to look for metallurgical causes of fatigue and insist that equally competent examination for mechanical causes be made. Until this is done, we cannot hope to make full use of our engineering materials." J. O. Almen, of General Motors Research Laboratories Division.

" " "

"I HAVE a solid conviction that trademarks and advertising have served the American people well, and by maintaining consistently high quality have won the consumers' approval. Imperfect as our system is, I prefer it to government control, standardization and any form of regimentation." *Representative Charles A. Halleck.*

" " "

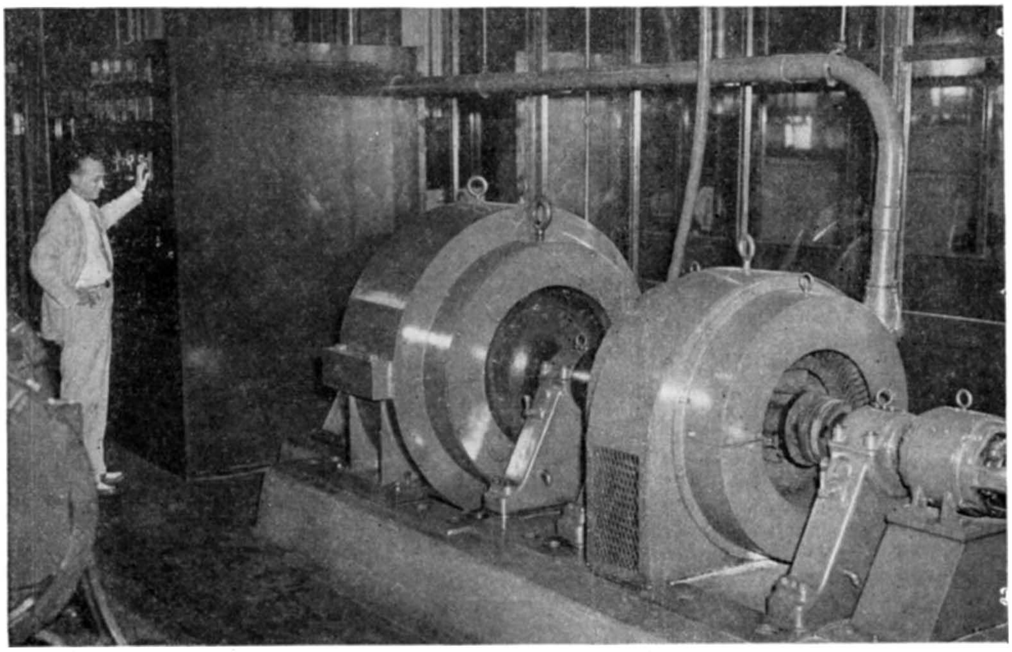
"THERE IS GOOD reason to believe that soon after the war, television will begin to realize its high promise. The technical accomplishments prior to Pearl Harbor demonstrate that television network operation is already practical, and undoubtedly much of the recent work in the field of electronics will directly or indirectly contribute to the further improvement of the art." T. A. Kennally, Vice-President, Philco Corporation.

" " "

"TODAY EVERY oil-producing area in the United States except the Texas Gulf Coast and West Texas is producing close to or in excess of its maximum efficient rate." *D. R. Knowlton, Director of Production of P. A. W.*

ELECTRONICS

Conducted by KEITH HENNEY



Frequencies all the way from 60 cycles to 50 million cycles are used in high-frequency heating. Here is a Westinghouse 3000-cycle generator which supplies power for hardening rocker arms

Electronics' Brightest Star

A Demonstration of Popping Corn Without Heat Has Led to the Development of Electronic Methods of Heating Many Materials — Metallic and Non-Metallic — by Means of High-Frequency Currents. Present Applications are Relatively High in Cost, Yet Bring Many Industrial Advantages

Who ever heard of popping corn without heat? Up until a few years ago, no one had, and when a group of electrical engineers demonstrated this unheard-of feat, everyone seeing the actual event was highly impressed; but, having seen it, how many saw that in a few years the basic phenomenon involved would be helping the war effort and pointing toward tremendous post-war possibilities?

The initial demonstration, reported in Scientific American, consisted in placing the pop-corn grains in a glass beaker and then placing the beaker on a support between two large metal plates which were a part of a high-frequency electron tube oscillator. The pop-corn absorbed energy from the electrostatic field to which the grains were subjected, this energy appeared as internal heat, and soon the grains were popping away inside their container without the slightest visible appearance of heat anywhere near the beaker.

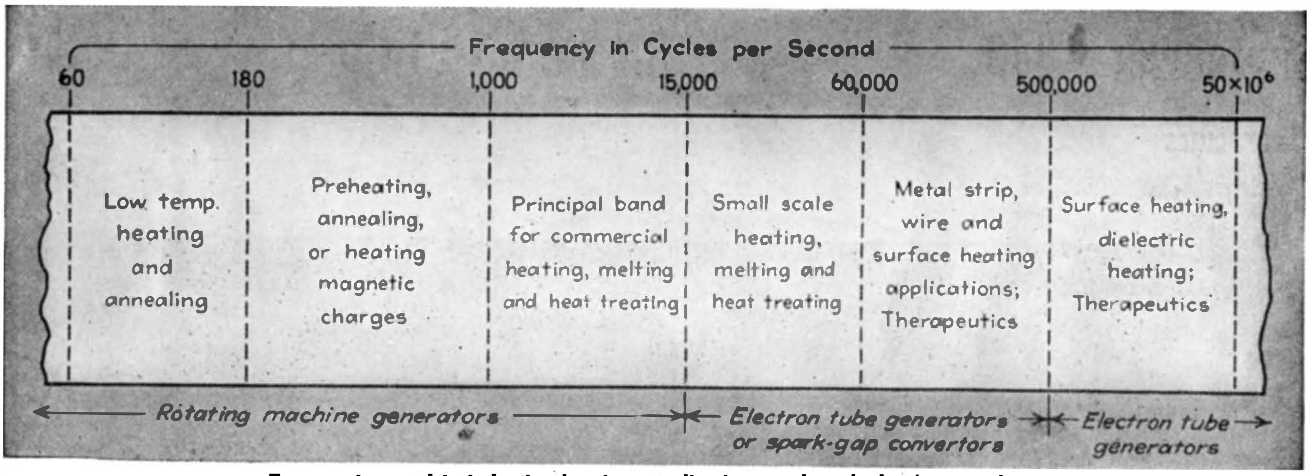
Popping corn by high-frequency heat is not a highly useful matter; but heating and drying food, plastics, lumber, rubber, and textiles, are exceedingly practical examples of this new and rapidly expanding use of electronics. So new is this application that no one is willing to wager how far into industry it will go, but anyone who bets on the short side is sure to lose his money.

High-frequency heating really started when engineers working on short-wave transmitters contracted artificial fevers. This was something new — the fact that living tissue in the vicinity of a high-frequency oscillator got warm, although the surface evidenced no rise in temperature. From this discovery came the many diathermy machines so widely used by hospitals, physicians, and clinics, and even rented out to people to use in their homes. This, however, was just a start. Heat treating by the use of high-frequency induction or by electrostatic fields has become fairly common since then and is bound to be as bright an application of electronics as welding control by electron tubes has become in the short space of a few years.

There are two general methods of utilizing high-frequency apparatus for heating. Metallic objects are best heated by placing them in an electromagnetic field such as is created when electric currents flow through a coil of wire. If only the surface of the object is to be heated, one technique is used. But if the interior is to be heated without any rise in surface temperature, another technique is required. In either case the heat is always under the control of the operator, and there is no transfer of heat as there is from flames or ovens.

If the object is a non-conductor, like a plastic — or like the pop-corn grains — then electrostatic heating is utilized. The object is placed between the plates of an electrical capacitor. The object, therefore, becomes part of the dielectric of the capacitor, and since the material out of which the object is made is not perfect, some of the energy flowing through it is absorbed and appears as heat.

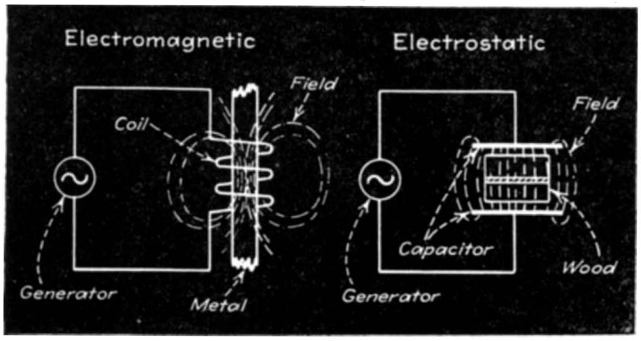
The equipment for heating by high frequencies is, to all intents and purposes, nothing but a tube oscillator similar to that employed in a radio or broadcast station. It consists of a rectifier to convert commercial frequency power into direct current and an oscillator to convert this power into alternating current of the frequency desired. Some installations are as powerful as the biggest broadcast station now in existence; others, of course, are much smaller. The frequencies required vary from 15 kilocycles (just



Frequencies used in induction heating, applications, and methods of generation

above the range of the human ear to hear) to 50 megacycles (six meters wavelength). This latter frequency is in the very high-frequency region now employed by television and FM stations and for other communication purposes.

From the standpoint of industry, the great virtues of this new kind of heat are as follows: The heat is generated directly in the object itself; no transfer of heat is involved, as is the case with open flames, hot plates, hot air, and older methods. Associated apparatus need not be heated as is true with an oven — only the object itself need get hot. The surfaces of the material need not be affected as is the case with flame heat. There need be no heat loss to the surroundings and thus the people who work with the equipment have cooler working conditions. No gases are involved and thus the likelihood of corroded surfaces, always a possibility when gases are present, is eliminated. Furthermore, the material can be heated from the inside-out and not outside-in as is necessary when the object is heated by placing it in an oven or by flames. Finally, the apparatus is exceedingly flexible so that objects of unusual size or shape or even physically inaccessible can be heated.



Any material can be heated by placing it within an A.C. electric field and applying sufficient current. Field may be either electromagnetic (coil) or electrostatic (condenser)

It is no wonder, then, that industry is looking with greedy eyes at electronic heating as a sign of progress. It must be remembered, however, that high-frequency heat is not cheap heat. The method enables industry to do things quicker, or with accurately controlled or localized heat. Thus, for a somewhat higher cost, the manufacturer in return obtains advantages which he cannot get with older methods. Radio-frequency heat may cost as much as 6 or 7 cents per kilowatt, which is in the luxury class so far as industrial heat is concerned; but the other advantages often outweigh the higher costs.

What practical operations can be performed with electrostatic heat? As a starter, consider the manufacture of compressed-wood airplane propellers. These are made up of maple sheets an eighth of an inch in thickness, impregnated with a phenolic resin and then dried. Then a phenolic glue is applied and the sheets are stacked, hand clamped, and placed in a kiln to tack the glue sufficiently to hold the sheets. Next the stack is placed on a carving machine which brings them to the required form. This form is placed between the plates of the high-frequency oscillator and power is applied to heat the entire preform up to the required temperature. Finally the assembly is placed in a die where it remains for three or four minutes. The propeller comes out in finished form without the undesirable surface hardening which resulted from previous methods using steam plates.

Before RCA engineers, co-operating with the Camfield Manufacturing Company, developed this process, a finished propeller represented an investment of 24 hours of time. Now the job can be done in 30 minutes. Thus a desirable saving in time was effected; but the added savings in labor and press facilities are not an inconsiderable part of the benefits secured.

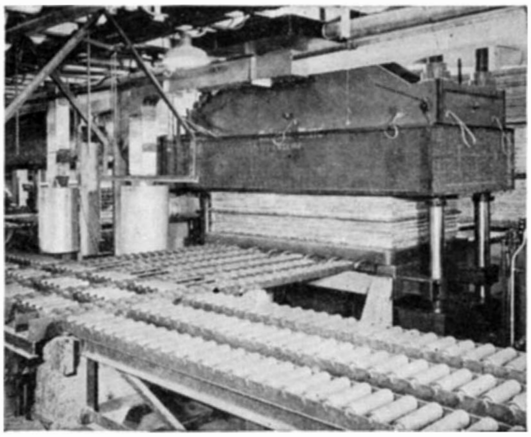
Similar procedures are followed in making other airplane parts such as propeller blocks, spars, ribs, wing structures, and so on. So beautiful is the surface of the wooden parts made by this process that very little or no surface finishing is required. The end product is a wood block or veneered board so hard that it is practically impossible to scar it. Thus it seems to be distinctly possible that post-war products of electrostatic heating will be desk and table tops, flooring, art objects, and the like.

Needless to say, plastics manufacturers look to this application of electronics as a great boon not only for the time-saving factor but for betterment of product as well. After the war, civilian goods made of plastics will be manufactured much faster than with older methods; the products will be more uniform, they can be made cheaper, and much larger moldings can be manufactured. Moldings as heavy as 50 pounds are possible with present equipment.

In the electronic plastic process, a preform or rough shape of the plastic article is placed between the plates of the electronic equipment and given a pre-heating treatment before the material is placed in the mold. This rough preformed "pill" becomes uniformly heated from the inside-out through all its thickness. This plastic preform, when transferred to the mold, flows easily to all the corners to produce a finished, strong plastic part with much less pressure and in less time. The time saving is evident when it is considered that seven minutes were required for a given article before electronics was applied. Now it takes a few seconds to preheat the article, and two minutes for molding and curing. In addition to the time saved, Bakelite engineers state that two other advantages are of extreme importance. These are: Plastic parts can be molded in thicknesses and sizes hitherto impractical with standard molding methods and conventional equipment. Existing molds and molding press equipment may be used to produce plastic parts which, before the introduction of electronic molding, would have required a long wait for the manufacture of high-pressure presses.

So important has been the application of electronic heat that one well versed in the field has stated that it is the greatest single advance in plastics in 29 years.

Now from these two examples it is not difficult to think of other applications. For example, right now there is great demand for dehydrated food as a means of saving shipping space, containers, and so on. High-frequency heating is playing its part in this new industry. Bakers have been interested in the possibility of making bread by electronic heat and thus doing away with large ovens which have to be preheated and which must inevitably absorb and dissipate much wasted heat. The problem here is whether the public will buy bread which has been baked from the inside out, since it is almost certain to be without crust. Experiments in bread baking are well in hand, and practical applications should not be long in coming into the open.



The entire bundle of veneer in the press is heated by induction to 160 degrees, Fahrenheit

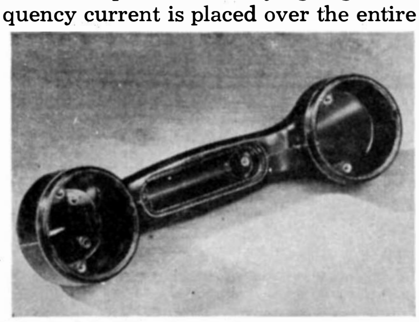
Another application into which much research work has gone is the quick drying of lumber so that the time lapse from tree to useful boards is lessened. Curing tobacco is still another use for electronic heat.

All these applications utilize the phenomenon that imperfect dielectric materials will absorb electric energy in the form of heat when placed in an electric field.

Now consider metals, which are not dielectrics and which require different treatment. Place one within a coil of wire and through this wire pass an alternating current. Lines of force go through the metallic article, creating currents in the metal. Since the metallic article has electrical resistance, the currents flowing in the articles heat up the material. Power is supplied to the object, in this case not by an electrostatic field but by means of an eletcromagnetic field. There are many applications of this form of electronic high-frequency heating.

Metals may be heat treated, hardened, brazed, melted, or soldered by this new method. Another application is the rivets, developed by Du Pont, which have in them an explosive. When placed where they are to do their work, which may be quite inaccessible, they may be made a part of an electromagnetic circuit with the result that the explosive is detonated. In the explosion that follows the rivet is expanded and thus set. Fifteen or 20 rivets per minute versus one or two in the same time are now possible.

For another use of electronic heat, consider the terminals on a small capacitor can. At RCA 100 of these could be done per hour by hand. Now a small blob of solder is placed on each terminal, then a loop of wire carrying high-frequency current is placed over the entire lot of terminals and all are soldered at one time. Now 2500 of them can be finished per hour.



Courtesy Bakelite Corporation

Heatronic molding turned out this complicated handset in 30 seconds

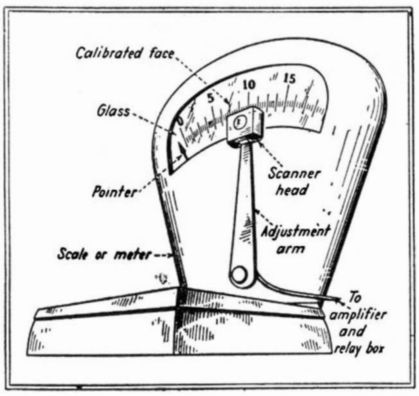
Thus far only a start on these new applications of electron tubes has been made. It is an auspicious start but it will be eclipsed by many things to come in the field of high-frequency heating.

⊕ ⊕ ⊕

PHOTO-ELECTRIC RELAY

Adapted to Batch Weighing, Metering, and So On

Designed by the United Cinephone Corporation, a light and compact two-unit photo-electric relay simplifies commercial and industrial operations which use pointer-and-scale type weighing devices for automatic control of processes such as batching and container-



Batch weighing by electronics

filling. The relay is readily adaptable for use in connection with weighing devices and may, obviously, be employed in conjunction with reasonably large meters used for measuring values other than weight. Construction is such that the relay may be applied externally to existing apparatus or incorporated within weighing devices or meters of the larger variety during manufacture.

SPECTROSCOPE DETECTIVE

Quickly Sorts Types of Filament Wires

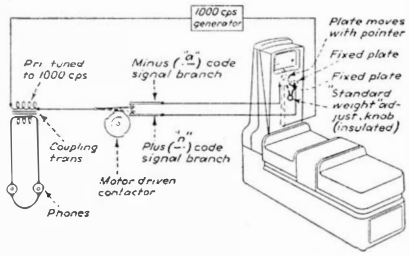
Increased production of high-power radio tubes being built at the Westinghouse Lamp Division has been made possible by the development of a detector that automatically sorts filament wire to determine whether it is made of pure tungsten or contains thorium.

The detection process consists of introducing a sample of filament wire into an electric carbon arc. As the wire burns completely, visible results are observed by means of a spectroscope. Two lines appear in the observed spectrum if the wire is pure tungsten while four lines appear if the wire contains thorium.

ELECTRONIC SCALE

Developed for the Blind, Has Other Applications

For many years airplane pilots have been guided by radio. The pilot wears a pair of headphones, and hears a dot and a dash (the Morse code for the letter "A') if he gets off course in one direction. If he gets off course on the other side, he hears the reverse or a



Circuit of electronic scale

dash and a dot (Morse for "N"). If he is on course he hears both signals and they join to produce a continuous tone in his ears. This was a remarkably useful concept but it was confined to this one use, until recently.

A scale suggested by a Buffalo blind woman and developed by the Toledo Scale Company, transmits a continuous tone to a pair of headphones when the weight of objects placed upon its platform exactly corresponds with any selected standard weight within the range of the scale. It sends the code-letter "A" when objects weigh less than the standard and the letter "N" when they weigh more. Obviously invaluable to the blind, the scale should also prove useful to people having normal sight where, for example, an industrial process requires weighing in the dark.

A small, light metal plate is permanently fastened to the pointer of the visual weight indicating device. Two "fixed" plates, insulated from each other and from a knob which permits them to be moved to a position corresponding with the desired standard weight, are positioned in close proximity to the plate fastened on the pointer. The three plates constitute a capacitor, with the pointer plate serving as the rotor.

The capacitor is connected in a circuit as shown, the cam being cut so that two fixed contacts, connected to the fixed plates of the capacity in a branch circuit arrangement, are opened and closed in a dot-dash-dot sequence.

The predominating code signal heard in the headphones will, therefore, indicate whether objects are under or over standard weight.

Conducted by EDWARD J. CLEARY

TRUCKS rumbling through the streets of oil-starved Germany today are operating on methane gas, obtained as a by-product from municipal sewage treatment plants. In Bradford, England, sewage disposal processes are yielding 500 tons weekly of vitally needed grease. In the United States a big steel plant is buying huge quantities of liquid effluent from a city sewage plant because existing industrial water supplies are inadequate to meet expanded output.

Dollars From Sewers

Modern Purification Techniques Have Advanced to the Point Where Valuable By-Products are Obtained from Sewage Treatment Processes. Fertilizer, Gas, Grease, and Processing Water are "Manufactured" from the Liquid Wastes Collected in Sewers

These three examples dramatize what might be considered the ultimate in deriving salvage from waste. They focus attention on one of the least suspected sources of valuable "by-products"—the city sewage disposal system.

Interestingly enough, it was not the war that led to the exploitation of salvage from sewage. For many years, while perfecting processes that would render innocuous the foul, water-carried wastes from city sewers, sanitary engineers both in the United States and abroad have been intrigued with the possibilities of reclamation of sewage by-products. In this country the prime objective of such activities has been to obtain revenue that would help to reduce operating expenses; modern sewage treatment plants are costly to build and to maintain. Abroad, where limited resources make conservation a national fetish, the objective has been to secure fullest utilization of waste.

Most readily salvaged and the most widely used by-product from sewage disposal plants is dried sludge, valuable as a soil conditioner and fertilizer base material. Next in importance is the utilization of digestor gas—averaging about 70 percent methane—utilized for operating internal combustion engines and for gas heating. Other conservation measures include the use of effluent for irrigation and industrial water supplies, and the recovery of grease. Meantime, investigations pointing to extraction of nitrogen, organic acids, growth-promoting substances, and the production of cement and ash are under way.

To appreciate the nature and application of these salvage operations, it is necessary to review briefly modern sewage disposal practice.

Water-carried wastes collected by the intricate network of sewers under city streets are either discharged into nearby streams (a practice that is no longer acceptable in the United States and which is being corrected) or brought together in a single conduit leading to a treatment plant.

Basic functions of such a plant are to separate the solids from the liquid, and then to digest the putrescible solids. Sometimes the liquid (containing solids in solution and in suspension) is treated further by aeration or filtration through which most of the organic material is oxidized and thus rendered inoffensive.

Some idea of the magnitude of the problem involved may be gained from the fact that in every ton (240 gallons) of sewage flow reaching a treatment plant, there is only about one pound of solids, but it is this small amount of putrescible material that must be removed by treatment. A little more than 25 percent of these solids settles out in the huge, concrete sedimentation tanks provided for this purpose. The balance remains with the liquid, either to be oxidized by a subsequent treatment process or discharged into a stream or river where natural processes of purification are active.

The solids settled out in the sedimentation tanks are called raw sludge. This highly putrescible material is transferred to closed, heated (80 degress, Fahrenheit) tanks where anerobic digestion takes place. During this process, which requires about 30 days, organic materials are broken down to yield a gas containing about 70 percent methane. A stable residue remains, which can easily be dried.

The dried, digested sludge, which resembles humus in appearance and texture and is free of any disagreeable odor, is widely used for soil conditioning and has the properties of a low-grade fertilizer. Chemical anaylsis reveals that it contains an average of 2.25 percent nitrogen, 1.50 percent phosphorous, and 0.70 percent potassium. This analysis does not, however, tell the whole story.

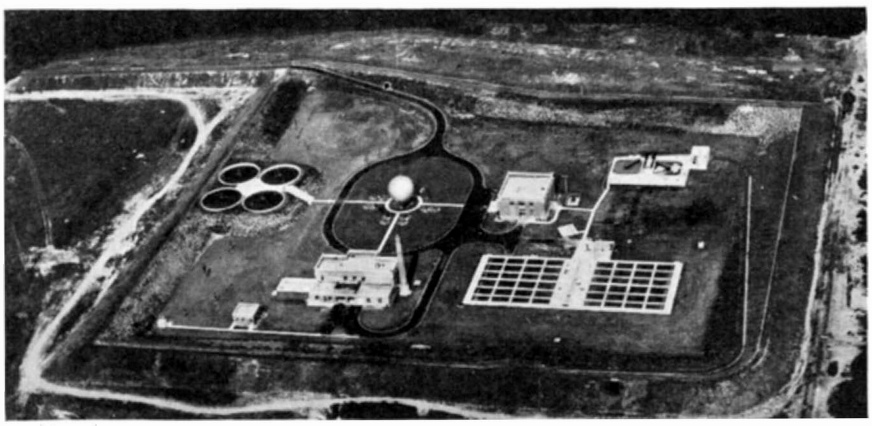
Puzzled by the observed fact that sludge has far greater fertilizing potentialities than those indicated by simple chemical analysis, researchers finally discovered that it also contains minute quantities of "micro-nutrient" elements (boron, copper, zinc, manganese, and others) as well as certain growth-promoting substances (indole, skatole, and so on), which exert a powerful effect on plant growth.

At many municipal sewage treatment plants the demand for sludge is now exceeding the capacity for its production. Farmers, florists, park departments, and golf clubs find it ideal for their needs. Victory gardeners, too, are using it to advantage. Esthetic and health consideration rule out the use of raw or digested sludge on vegetables and fruits that are to be eaten uncooked, but otherwise there are no limitations to its use.

Some cities, of which Milwaukee is a notable example, have gone into the production of a high grade of fertilizer using sludge as a base. The Milwaukee product, known as "Milorganite," is reinforced to provide a fertilizer containing 6.0 percent nitrogen and 2.0 phosphoric acid, and is marketed throughout the United States and Canada. Chicago sells and ships huge quantities of dried sludge to Florida where fertilizer manufacturers use it as a base or "filler" material.

The use of sludge gas for operating stationary internal combustion engines has won wide acceptance in the United States, the most recent survey in 1941 showing the installation of 180 sludge gas engines. The majority of engines are under 500 horsepower but the range is from three to 1440 horsepower. They are used to generate electricity for plant operation and in many instances are directly connected to pumps and blowers.

New York City, with a total installed capacity of 11,840 horsepower, outranks all other municipalities in the use of sludge gas. One plant, at Coney Island,



Sewage treatment facilities for a large city. Sedimentation basins are at right, circular digester tanks at left, and spherical gas storage tank in the center produces 3660 horsepower; another, at Tallman's Island, contains eight engines totaling 3840 horsepower, and the new Jamaica plant, which will soon go into operation, has three engines, each of 1440 horsepower.

Nearest competitor in size is the Mogden plant in London, where ten engines, each of 675 horsepower, are operated.

An estimate of the potential power production capacity of a city may be made on this basis: Per capita gas production from sewage solids digestion averages one cubic foot per day, which means that for every 17 persons there is the equivalent of one horsepower-hour of power. A city of 50,000 thus would have a sludge-gas power capacity of 2900 horsepower-hours per day.

Fuel value equivalents of sludge gas, which has an average calorific content of 650 British thermal units per cubic foot, are listed as follows in a report of the American Society of Civil Engineers: 1000 cubic feet of sludge gas = 1000 cubic feet of artificial gas = 590 cubic feet of natural 1100 B.t.u. gas = 6.4 gallons of butane = 5.2 gallons of gasoline = 4.6 gallons of Diesel oil.

Cost of electrical energy derived from sludge-gas generating equipment is about 0.6 cents per kilowatt-hour. This is lower than the commercial rate of 1.0 cent available to cities of 100,000 to 200,000 population.

Aside from the use of sludge gas in stationary engines, it also may be employed in internal combustion engines in vehicles. Germany, lacking gasoline and anticipating leaner days ahead, demonstrated this years ago.

In 1935, for example, about 100 trucks in the Ruhr district alone were equipped to use this gas for fuel. At least five cities had equipped their municipal vehicles for such operation.

Local sewage-treatment plants are the "filling stations" where the gas is compressed and stored in small cylindrical steel tanks. Each tank holds about 500 cubic feet of gas at a pressure of 400 pounds per square inch. With three tanks of gaseous fuel a five-ton vehicle can travel about 225 miles. The cost of operation per 100 miles is $5.71 using the gas, compared with $9.95 for oil. Necessary changes to convert an oil-operated engine for the utilization of gas are comparatively simple.

In London during the last two years it is reported that sludge gas has been lightly compressed in special vapor-proof bags for the operation of motor vehicles.

In this country the only city thus far that has given serious thought to the utilization of sludge gas for vehicle operation is Atlanta, Georgia. Studies made by Dr. Harold Bunger, director of the state engineering experiment station at the Georgia School of Technology, reveal that conversion of all city motor equipment to compressed-gas operation would yield a net saving to this one community of $8000 annually.

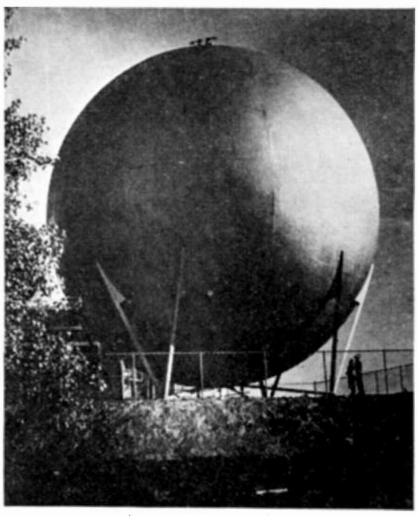
It was proposed that gas from one of the Atlanta sewage treatment plants should be compressed to 3000 pounds per square inch and stored in steel cylinders nine inches in diameter and five feet long, each cylinder holding 14.5 pounds of methane.

The idea was abandoned, however, when the city decided to burn the gas for steam generation in the boilers of a nearby municipal waterworks. This practice is expected to provide a saving of over $6000 annually in fuel bills and is much simpler than would be the gas compressor and bottling procedure.

Removing digested sludge for sale as fertilizer

Estimates show that, for a population of 100,000 people, from 180 to 365 tons of crude fats are present in the sludge. Generally, it is not, however, profitable to separate grease from sewage. The value—two or three cents a pound—hardly justifies the effort; furthermore, the grease can be digested with ease along with other solids and thus provide a richer yield of sludge gas.

In wartime, on the other hand, the value of grease is enhanced because it is a source of glycerine used in powder making, medicinals, and other needed products, and thus it is that New York, Chicago, and several other cities are now interested in grease recovery from their sewage disposal plants. In New York City, for example, the matter has advanced to the point where contracts are being considered with private vendors for the sale of about 50 tons of grease a month. This grease has a glycerine content of 5 to 4½ percent, compared with the 10 percent obtainable from commercial fats. The army, too, is salvaging grease from the sewers at troop cantonments.



Many modern sewage plants provide storage facilities such as this spherical tank in order to furnish a constant supply of gas for engines

In England, where fat shortages are more severe than here, grease from sewage is playing a major role in the war effort. One plant alone—that at Bradford—is supplying 500 tons weekly. This, however, is an exceptional case, because the Bradford sewage contains immense quantites of lanolin fat. The latter originates from washing wool, one fifth of the world's production of which is handled in that city.

Bradford began grease reclamation as far back as 1903. The first year's sales produced $1220 revenue but in recent years the revenue has exceeded $400,000 annually. Grease removal is accomplished by first adding sulfuric acid to the sewage to crack soaps and precipitate the wool waxes. The resulting sludge is then heated and filter-pressed through cotton cloth. Liquid grease and water are discharged in the process, after which the grease is treated for removal of impurities and then barreled.

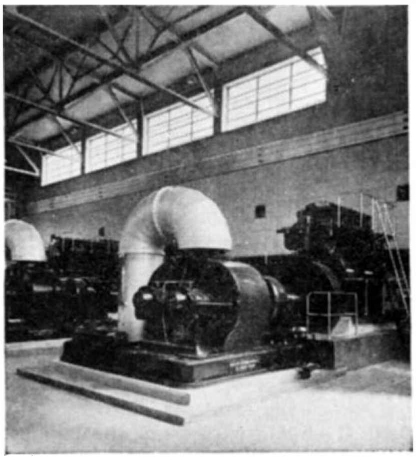
Incidentally, the pressed filter cake is dried in the open and then passed through a grinder to produce a material that finds ready sale as a fertilizer. The latter sells for $7.50 a ton delivered, and in peak years has produced revenues up to $68,000.

In the semi-arid regions of the West and Southwest, the effluent (liquid) from sewage treatment plants is profitably employed for irrigation purposes at a number of places. However, sanitary and esthetic considerations limit its use to crops that will not be eaten raw or to grasses used for cattle feed.

One of the most interesting operations of this kind can be observed at Vineland, New Jersey, near Philadelphia, where a sewage farm has been operated for several years, following successful use of this scheme at nearby state institutions. The sewage from this town of 8000 people is first settled to remove the coarser solids and then distributed over a 40-acre field by means of an underground tile distribution system. The soil at Vineland is a sterile, coarse sand well adapted for drainage but not suited to farming unless irrigated and fertilized. Conditions, therefore, are ideal for sewage disposal combined with farming. Because of local commercial conditions, sweet corn is the major crop. Soybeans and forage have also been produced with good success.

A unique effluent reclamation operation is conducted at the Grand Canyon of the Colorado in Arizona. Here the Santa Fe Railway uses highly purified effluent from a sewage treatment plant for industrial needs in its shops, for flushing toilets, and for lawn sprinkling. The sewage effluent is used in place of fresh water which would otherwise have to be pumped vertically 4000 feet from springs at the bottom of the canyon, or else transported in tank cars from Flagstaff, Arizona.

One of the most spectacular examples of effluent reclamation for industrial purposes has resulted from the war. A large steel mill, faced with a dwindling supply of ground water, and too far from an ample source of surface water, laid a pipeline to a nearby sewage plant to obtain 40,000,000 gallons daily of effluent. This provides enough process water for expanded steel production and at the same time brings a nice financial return to the city, which heretofore discharged the plant effluent as waste in a waterway. At the agreed rate of sale the city will net about $24,000 annually.



Gas obtained from the treatment of sewage is used to drive the engines of these huge blowers in a disposal plant in New York City

Taking advantage of the fact that diluted sewage effluent promotes the growth of plant algae and protozoa, all of which serve as fish food, the city of Munich, in Germany, found it profitable to combine fish culture with sewage disposal. The Munich sewage is first treated in sedimentation tanks to remove the settleable solids, and then is conducted to fish ponds covering a huge acreage of ground. The ponds are stocked with carp, a scavenger-type fish that displays great hardihood in polluted waters, and these are fattened for sale in local markets.

City sewage salvage activities are not the only concern of the sanitary engineer; the salvage possibilities from the huge quantities of industrial wastes that now pour untreated into our rivers are equally important in many respects.

These wastes are generally highly pollutional in character, thus making streams unfit for water supply, fish life, and recreational purposes. Legislative measures already taken, and a growing public resentment to such despoiling of our streams, make it inevitable that industry must undertake this abatement on a far greater scale than heretofore.

Strongest incentive for industry to provide treatment of its waste is to discover how this treatment can be made to yield some financial return in recoverable products that will help defray the cost. Progress is being made in this direction.

One of the classic examples of what can be done concerns itself with the Corn Products Refining Company at Argo, Illinois. For years this company, in co-operation with the sewage disposal experts of the Sanitary District of Chicago, has been engaged on the problem of reducing the pollutional load resulting from the processing of 80,000 bushels of corn daily. The pollution at first was equivalent to that from a population of about 400,000 people. An improved settling process was evolved whereby enough solids were recovered to reduce the population-equivalent of pollution to 270,000; furthermore, in this particular instance the reclaimed material produced an excellent stock feed. Later improvements, including the evaporation of washwater to a syrup that could be mixed with hulls and gluten solids, reduced the pollution to 75,000 population-equivalent and permitted the manufacture of more stock feed. Recovery of this by-product has been profitable and has also eliminated the need for treatment measures that would have cost nearly $3,000,000.

Treatment processes that yield a financial return and at the same time curtail pollution are being used with varying success in several industrial operations, including paper-making, sugar-beet processing, steel-pickling, canning, brewing, and chemical manufacturing. Much remains, however, to be done.

Industrial waste treatment for recovery as well as for polution-abatement ranks as one of the most important and challenging of our post-war problems.

Considering the success that has crowned the salvage efforts of sanitary engineers and chemists in dealing with the dilute, heterogeneous wastes from municipal sewers, some "miracles" in reclamation may be anticipated from the more concentrated and homogeneous industrial wastes.

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WATER CONSERVATION

Methods of Double Use Employed by the Army

IN AN effort to curb wastage as well as to provide for most effective use of water where supplies are limited, Army engineers have been working on several water conservation schemes.

One of these has resulted in the design of a communal lavatory for theater-of-operations cantonments in which waste water from wash trough and showers is collected in a tank and used again for latrine flushing purposes. All waste water is drained to a 1000-gallon capacity concrete tank located beneath the floor of the lavatory, and when the tank becomes filled an automatic siphon discharges the water through an adjoining concrete pit latrine; the outlet end of the latter is connected with the camp sewer system. Dual use of water for washing and flushing will result in a saving of at least 10 gallons per man per day, which for a large camp represents a substantial amount.

Laundry waste water reclamation has also been given attention. Processing this waste water for re-use in washing laundry or camp equipment also is estimated to save about 10 gallons per day per man. The treatment process involves segregation of the laundry waste from other waste water, addition of a lime precipitant, flocculation with air, and sedimentation.

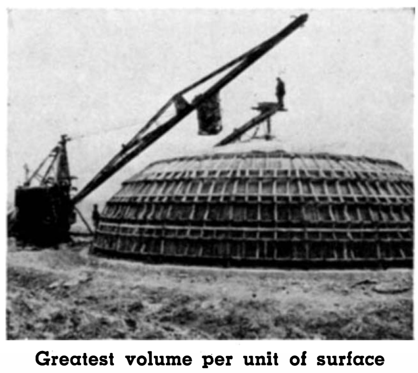
MUNITIONS STORAGE

Facilitated by Design of New, Economical "Beehives"

CONCRETE "beehives" for munitions storage represent one of the innovations in underground storage facilities adopted recently by the army and navy. Developed by the Corbetta Construction Company of New York City, the patented design has been turned over to the federal government for use without restrictions as a contribution to the national war effort. About 2000 of these structures have been built or are now under construction.

Prior to December 1942, when the beehive design was proposed to the army, munitions generally were stored in semi-cylindrical barrel-type concrete igloos; the standard igloos are 80 feet long, 26.5 feet wide, and 12 feet high. The beehive, which resembles half a grapefruit resting on the cut side, is 52 feet in base diameter and is 16 feet in height. In order to simplify construction, the dome-like structure is composed of a series of polygonal sides instead of being a true spheroid.

Because it approaches a sphere in shape, the beehive is the most economical form for a container, in that it provides the greatest volume of storage per unit of surface. Although the floor area of the beehive is just about the same as that of the standard igloo, the volume of the beehive is about 10 percent greater. Furthermore, the beehive requires only 1300 pounds of steel and 180 cubic yards of concrete as compared with the standard igloo, which requires 4200 pounds of steel and 217 yards of concrete.



Greatest volume per unit of surface

What Is Hardness?

Strictly Speaking, Science Doesn't Yet Know. There's Much More Philosophy to the Subject Than Meets the Eye. We Have Testers that Measure Hardness—or so We Think—and then We Define Hardness on a Basis of their Methods, Rather than Vice Versa

S. R. WILLIAMS

Fayerweather Laboratory of Physics, Amherst College

OF ALL tests for suitability of materials for a given purpose and for maintaining standards, hardness is the leader.

Just what, however, is hardness? The man on the street has no difficulty in understanding the term, or so he supposes. Everybody knows the difference between a hard and a soft bed; hard, medium, or soft eggs; hard and soft woods. Our thumb has been an indenter in testing fruit ever since we were able to eat an apple. "If you must pincha da fruit, pincha da cocoanut."

With all this emphasis on hardness, we still must confess that we do not know what hardness is. That is, if we require a specific definition—one expressed like those for other physical qualities, in terms of fundamental units like length, mass, and time.

By trial and error primitive man found that knives made of flint held their edge much better than other kinds of stone. They penetrated other materials much better than stone softer than flint. Man in the iron age found that, by various manipulations of his iron, he could make it (steel) harder than other samples. The soldier armed with a steel blade quickly found out that the blade of hardest steel had smaller "nicks" in the cutting edge when he crossed swords with his adversary. Thus there was borne in on man the idea that the more resistant a body was to penetration by another body, the harder was the body offering resistance. Thus, like Topsy, there has "just growed" an idea that hardness can be measured by some means wherein the resistance to penetration by some form of indenter would serve as the basis of hardness measurements.

Reaumur, the man who wrote fascinatingly about ants, evidently took the idea of the crossed swords and crossed two similar, triangular-shaped, pieces of steel and pressed the edge of one into the edge of the other. The piece showing the smaller permanent deformation of the two was the harder body. This was a procedure that many of us as boys carried out when we bragged that the steel in the blade of our jackknife was better than the one possessed by our friend, and we proceeded to cross the two blades and show that ours had a smaller indentation in its edge.

When, in the beginning of the 19th Century, mineralogists wanted to classify and identify their minerals, they found that the relative values of hardness was a great help. So arose a method perfected by Mohs in which the ability of one mineral to scratch another was made the basis of hardness measurements. Mohs used ten steps in his scale of hardness, beginning with talc as the softest and ending with diamond as the hardest. If a mineral scratched fluorite and was scratched by apatite it had a hardness number 4+ on Mohs' scale. On further consideration it will be seen that the scratch method is also a penetration method.

These methods have been described because in our evolving process of hardness measurement we have arrived at a definition of hardness based on the method whereby we measure hardness (or at least we think we have been measuring hardness), instead of first defining hardness as a certain physical property and then proceeding to find means for measuring it.

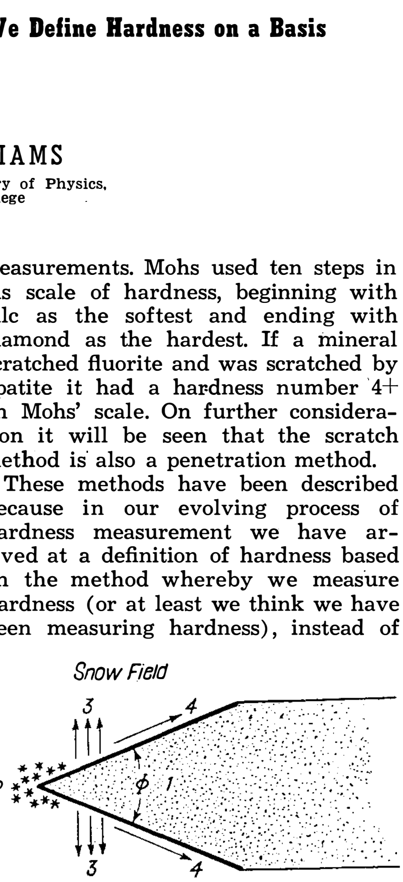


Figure 1: **Penetration resistance**

Thus we have two definitions which are essentially the same: 1. Hardness is resistance to penetration by a given indenter. 2. Hardness is resistance to permanent deformation—from which it follows also that hardness is resistance to being scratched or penetrated by a moving indenter.

In the development of methods of hardness measurement, Brinell put on the final touch. Using a definite-size hardened steel ball as a penetrator, and a definite load, the diameter of the indentation is taken as the basis for hardness measurements. So far as penetration methods go, each instrument for measuring hardness emphasizes something different. One stresses load applied to the indenter, another the depth of indentation, others the shape of the indenter, and some the material of the indenter.

Keeping the general method for the measurement of hardness in mind, we shall proceed now to ask: What lies back of hardness? What makes a bed hard or soft? How do we measure the hardness of cooked eggs, of butter, and of peaches? If our hip bones and shoulder blades do not penetrate the mattress on our bed, we say it is hard. If the butterknife doesn't slip through the butter easily, we say the butter is hard. Soft woods seem more porous than hard ones, and so are more penetrable. Resistance to penetration seems to be the basis generally understood when measuring hardness.

A snowplow, as it is pushed into a snowdrift, is a penetrator and we can ask: How hard is the snowdrift? We shall be within our rights if we say that its hardness is measured by the resistance offered to the penetration of the snowplow. We can also ask: What are the factors which determine the resistance to the snowplow?

Figure 1 shows a double-winged snowplow pushing into a snowdrift. At least five factors influence the ease with which the plow pushed in:

1. The angle between the two wings. The smaller it is, the easier the plow pushes in.
2. As the edge formed by the two wings goes in, the snow crystals must be torn apart. Solid ice would, comparatively speaking, be extremely hard.
3. The snow crystals are pushed back over each other (intercrystalline friction). The greater this intercrystalline friction is, the more difficult it is for the plow to penetrate.
4. The entrance of the plow starts snow particles sliding over the surfaces of its two wings. This frictional force is a part of the resistance offered.
5. There is a packing and compression of the snow particles. This takes energy.

FACTORS 1 and 4 are very much dependent upon the indenter and not upon the substance being tested. The thing we really are interested in is the separation of the particles of the material tested as the indenter penetrates it.

Dealing then with a substance like steel, if we press a hardened steel ball into the surface of the test specimen, we find that the factors in which we are most interested are those which we

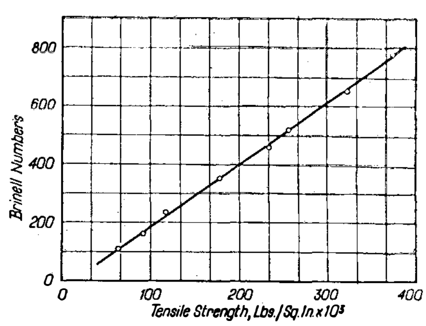


Figure 2: **Proportional relation**

call inter-atomic, and perhaps inter-electron, forces and are not much different in effect from those in our case of the snow and snowplow. If no forces exist between the particles that make up a substance, then there can be little or no force of resistance to penetration by any indenter whatsoever.

A great deal of work has been done in studying the relations between hardness as measured by an indenter method and some of its other physical properties. Among those comparative studies is that of the relation between hardness and the tensile strength of a series of steels (Figure 2). The tensile strength of a substance is its resistance to being pulled apart. This resistance to being torn apart has to do with the "snow and snowplow" factors 2, 3, and 5; with 5 playing a very minor part. The big factors, both in hardness testing and in measuring tensile strength, are 2 and 3; and therefore we see that hardness as measured by the Brinell instrument appears to be proportional to the tensile strength of the same material. This fits in with the idea of resistance to permanent deformation. A permanent deformation by the indenter of a hardness tester indicates that some of the particles have been torn from their neighbors and some have slid over their neighbors. The same holds true for tensile strength measurements; hence the relationship found in Figure 2.

During the past 25 years X-ray analysis of crystals has opened to us a vast, new world. Von Laue and the Braggs were able to show us that the atoms in most substances are arranged in an orderly, crystalline manner. Take, for example, the ordinary salt we use in our food. Figure 3 shows how the sodium and chlorine atoms are laid up in an orderly cubic fashion in a crystal of salt. Let the black balls represent the chlorine atoms and the white ones the sodium atoms. The symbol for salt is NaCl. That is, one atom of sodium and one atom of chlorine form a molecule of salt, but which chlorine goes with which sodium atom to form the molecule? We don't know, and therefore to speak of a molecule of a substance in the solid state is meaningless.

Hence, when the indenter of a hardness test penetrates the surface of a salt crystal, it is acting for the most part against inter-atomic forces. Intermolecular forces are meaningless.

The inter-atomic bonds are, in the final analysis, the bonds with which the chemist is familiar, yet there is very little to say about the relationship of these bonds to hardness. This goes to show how little we know concerning hardness and how great is the need for basic research on it.

Take, for example of inter-atomic bonds, the great hardness of the diamond. Why is the diamond so hard? We have at least two fairly good reasons. First, the carbon atom is small and so the distance between the centers of atoms is small, and (so far as we know) the inverse square law holds for the forces between them. Second, the atoms are tied together by very strong covalent bonds (sharing of electrons). The diamond has its atoms in a very tight and compact form. Figure 4 shows the arrangement of the carbon atoms in a diamond. Each atom is attached to four of its neighbors by these covalent bonds, which gives it tremendous resistance to being "pushed around." The arrangement of carbon and silicon atoms in the abrasive compound, silicon carbide, which is almost as hard as diamond, is similar.

Figure 3

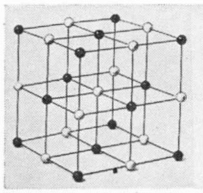
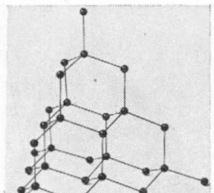


Figure 4



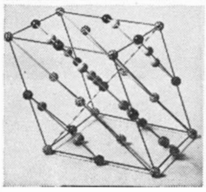


Figure 5

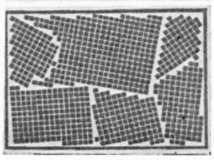


Figure 6

The thing which seems to go with these bonds which hold the atoms of carbon together so tightly is the number of electrons which flank the central nucleus of the atoms. If the outer zone is complete—that is, if it has eight electrons—that atom is an isolationist and doesn't want to have anything to do with its fellow. This is not the case with the diamond atom. Carbon is a highly gregarious atom. Each atom has four electrons in the outer zone and these pair off with the electrons of their neighbors, and it is these co-operating, covalent bonds which hold the diamond atoms so closely together and with such tenacity.

On the other hand, copper has only one electron in its outer zone, no such strong bonds are formed between the atoms of copper, and so we find copper soft, malleable, and ductile.

Size of atoms, and atomic bonds, are not, however the whole story of hardness. What has happened to a metal in which hardening has been increased by cold working? The atoms are still the same atoms as before the cold working occurred. Hardness in a metal seems to depend upon the resistance to slip between adjacent atom planes. How can this resistance to slip be changed?

In the first place what are atomic planes? We digress for four paragraphs.

We have seen that, in salt, the atoms are laid up in an orderly cubic arrangement. If now the model is turned, a position will be found where the atoms appear to line in planes. In Figure 5 is shown a model of calcium carbonate ($CaCO_3$), or Iceland spar, turned so that its atoms line in a plane. There are certain planes in a crystal which allow the atoms to slip over each other more easily than along other atomic planes. We speak of them as "slip planes."

It must be kept in mind that the models in Figures 3 and 5 are ideal. In nature and as we manufacture crystals they are not so perfect. As an example, take the case of steel. It is crystalline, as are practically all other solids, but the piece of steel as it is furnished to us from the steel plant is not one complete crystal, as is our model. Steel may be represented by Figure 6, in which we see that the metal is made up of cubic crystals of steel (crystallites) whose cubic axes in one crystallite are not in the same direction as the others. As a whole, the crystallites are arranged in a hit-or-miss fashion, as shown.

Now, what happens when the spherical indenter of a hardness tester penetrates a group of steel crystallites? The answer seems to be that the atoms composing the crystallites of steel are pushed around, or the slip planes in each crystallite become effective and the atoms move over each other along these slip planes. These slip planes can easily be seen under the microscope.

If in any way we can alter the ease with which the slip planes operate, we can thereby change the hardness of a solid. There are at least two distinct ways by which this can be done—first, by distorting the slip planes into curved or irregular surfaces and, second, by putting something in between the slip planes (figuratively speaking, throw grit in the bearings).

Returning to the case of cold rolling, or cold working, of steel, in doing this we put strains into the crystallites, which distorts the atomic planes and thus increases the resistance to slipping. The result is increased hardness. The same slip can be impeded by dissolving in the metal other constituents, usually metallic. For example, copper is alloyed with silver to make the latter hard enough for coinage. Figure 7 shows what happens to the atomic planes—at the left, when the introduced atoms are larger than those into which

Figure 7

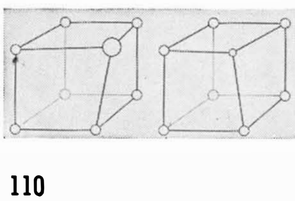


Figure 8

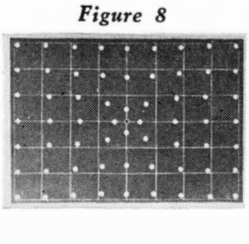


Figure 9

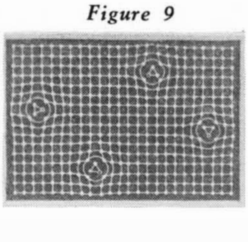


Figure 10

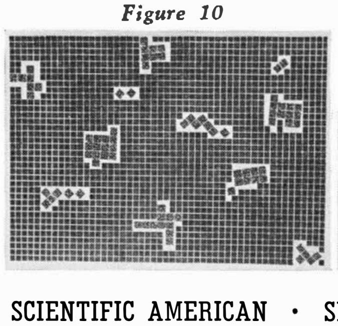
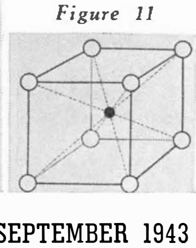
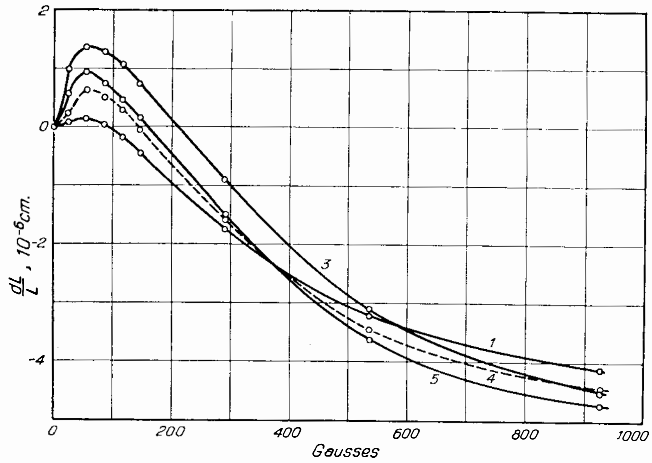
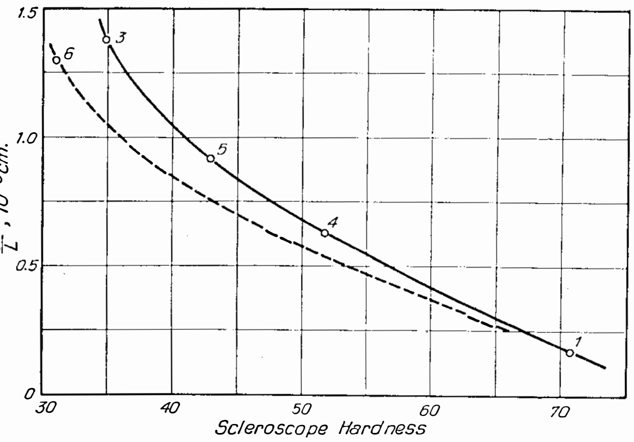
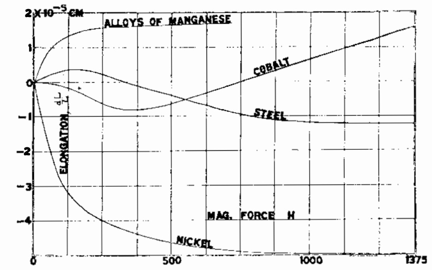


Figure 11







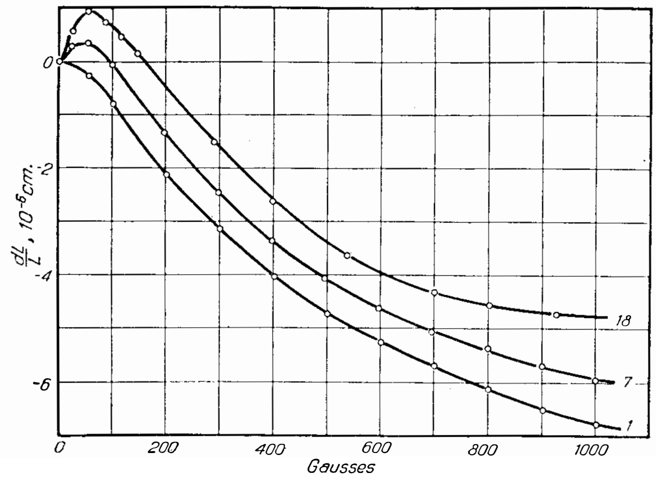


Lower left: *Figure 12*

Upper left: *Figure 13*

Upper right: *Figure 14*

Lower right: *Figure 15*



they are introduced, and at the right when the reverse occurs.

Figure 8 shows this condition in another way. The straight lines are the positions of the original atomic planes, but when a foreign atom is introduced, all the neighbor atoms are pulled out of the former cubic arrangement and find themselves on curved surfaces. This impedes the movement of the slip planes. Further, in some cases it is possible, by suitable heat treatment, to precipitate the dissolved constituents throughout the structure, causing more distortion, as shown in Figure 9. Not only is there a distortion, but the dissolved constituents thus precipitated act as a mechanical obstruction to the slipping of the planes, as shown in Figure 10.

Returning once more to our question about cold working of metal, the answer seems to be that, in the process of cold rolling, hammering, or drawing, distortions are set up and disregistry of atomic planes is produced by these mechanical processes which help to impede the slipping along these atomic planes. Finally, if the foreign atom introduced is too small, it may just get in between atomic planes as in Figure 11, and we have "grit in the bearings."

When carbon is added to iron, it is interesting to see how little of it (less than 1 percent) is necessary to increase the hardness many fold.

It was stated earlier that hardness depends on inter-atomic, inter-electronic forces, and thus far we have dealt with forces of the inter-atomic variety. From here on we shall deal with inter-electronic forces.

As far back as 1847 Joule made the interesting discovery that a steel rod would change its length when subjected to a longitudinal magnetic field. Later it was discovered that other ferromagnetic substances changed their dimensions in a magnetic field. Figure 12 shows how various ferromagnetics change their length for various field strengths. Joule, in describing his discovery, made the significant observation that, the harder the steel was, the less was the increment in length of the rods.

Following this notation of Joule's, the writer found in studying the relation between magnetic increments in length and the hardness of a series of steel rods, that the two went hand in hand (Figures 13 and 14). Furthermore, if we take for granted that the softer the steel rod is, the greater is the increase in length of the rods, then, as Figure 15 shows, by reversing the magnetic fields on a piece of steel several times and then measuring its change in length, the increment of length increases with each series of field reversals. That is to say, by magnetically working a piece of steel it is softened. This point of view was confirmed by Herbert using his pendulum hardness tester.

Even with what we already know about hardness, much basic research remains to be done on the subject. One of the best places to get such work done is in the industries and in the development of research laboratories in industry. The firm or management which had only just a little edge on their competitors in the knowledge of what lies basically at the root of hardness would have the jump on those competing against them.

Whatever hardness testers measure, the fact remains that their ability to show whether a structural piece of steel or aluminum or some other metal is suitable for a given purpose is outstanding. They will tell at once whether the quality of a certain consignment of steel is up to specifications or not. They give most valuable information regarding such properties as tensile strength, but wouldn't it give a great impetus to the whole subject if we could really define hardness?

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GOLDEN ROD

Experimental Plantings Have Been Completed

UNDER the program authorized by Rubber Director William M. Jeffers, the Forest Service has planted selected strains of goldenrod on about 550 acres in the vicinity of Waynesboro in Burke County, Georgia. Small experimental plots of two to ten acres were planted by the Bureau of Plant Industry, Soils, and Agricultural Engineering in South Carolina, Alabama, Mississippi, Louisiana, Texas, and California.

Only the leaves of the plant are used in processing for rubber. They may be processed immediately or stored for processing later. This year's leaf harvest will be sent to the Department's Southern Regional Research Laboratory at New Orleans for further extraction and utilization studies. In the present experimental growing operations, every effort will be made to produce a maximum quantity of planting stock, in case a larger program should prove desirable in 1944.

Hard, Corrosion-Resistant, Slippery

The Story of the Conversion of That Popular Glamour Metal, Chromium, to an Essential Machine-Shop Material for the Production Front—Some of its Unsuspected Properties and New Uses, its Conservation Aspects, and its Future Place Among Industrial Materials

ALTHOUGH this is an era of new industrial materials, there are less glamorous but no less significant parts of the materials picture which concern new applications of old materials—applications so fundamental as to raise the stature of the old material in its new application to that of a new industrial material. Outstanding in this class is the fast-growing use of chromium plate for a variety of industrial applications that are entirely independent of the familiar decorative appeal of this coating.

Chromium plate is today serving industry in many ways that are new and for which no other material of comparable properties exists. "Chrome plate" is the beautifully lustrous finish that made American automobiles and electric appliances the shiniest on earth; but it is also among the hardest and most wear-resistant materials known, and its frictional qualities (slipperiness or bearing properties) place it in the ranks with the best among all other metals.

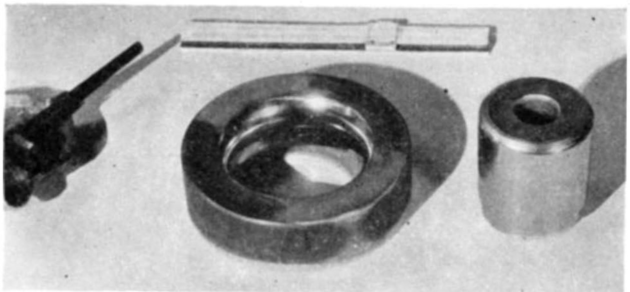
But most important of all: Chromium plate in its wartime overalls is providing the life-saving answer to a critical shortage of small tools and dies and is extending the utility of this country's tool-steel alloys—tungsten, chromium molybdenum, vanadium, and cobalt—machine tools, and manpower by truly tremendous amounts.

Dr. Arthur W. Logozzo, of the Hartford Chrome Corporation, a pioneer in the industrial use of chromium plate, characterizes this bright metal coating as "the greatest life prolonger of new equipment and one of the greatest single salvage mediums" we have today. Chromium plated gages, for example, outlast un-plated gages by four times or more. This means not only 400 percent more production from the particular quantities of critical metals present in the gage, but also circumvention of the painful problem of obtaining new gages quickly from today's heavily overburdened toolmaking facilities. Then, too, gages are expensive and the cost savings in prolonging their life are not to be ignored.

The story is the same with cutting tools, forming dies, and molds, some of the plated tools giving ten times the life of those unplated. Most ammunition manufacturers who do any drawing of copper, brass, and steel, for example, chromium plate their new dies and punches, enjoy enormous life extensions (since they replate the tools several times), and find in addition that the plating on the dies eliminates sticking during drawing.

For salvaging machinery parts or dies that have been worn or mismachined undersize, chromium plate deserves an Army-Navy "E" all its own. Production rejects that would otherwise be scrapped because, let us say, the parts are not thick enough, are now heavily chromium-plated to the correct dimensions and put into use. Worn bushing bores that are too large are chromium-plated to reduce the inside diameter and are thus completely reclaimed.

Potentially the largest industrial field for chromium plating may be its use as a production finish on aircraft, Diesel, and automotive engine machinery and pump parts that must resist wear or corrosion. Many manufacturers of war-vital machinery now obtain smoother operation and much longer life by using chromium-plated pistons, rods, shafts, cylinders, press rams, guides, cams, bearing rollers, and so on. The recent development of *porous* chromium plate, which provides a hard, wear-resistant, and oil-retaining surface for Diesel cylinder bores, pistons, rings, and similar parts, is expected by many to have the greatest influence of all on the high place chromium plate may ultimately occupy among industrial materials.



Examples of chromium-plated drawing dies

The *quality* of the chromium deposited for industrial applications is essentially the same as that which is plated for ornament. For many years people thought there was a necessary difference between the hardness of industrial and of decorative chrome plates, and hence applied the term "hard chrome" to industrial coatings and "decorative chrome" to the brilliant ornamental plate. Actually, tests have proved that the bright plates are among the hardest available (1000 to 1025 Brinell), and bright plates are consequently universally applied as the best for industrial uses.

There is an interesting reason, though, for the general impression that decorative chromium is softer than industrial. A file drawn across the surface of a brilliant chrome-plated belt buckle or hub cap will invariably scratch it, while the same file will fail to leave its mark on an ordinary chromium-plated drawing die or machine spindle. The natural conclusion from this is that the industrial plate is harder than the ornamental, but the facts are that the ornamental plate is *thinner* than the industrial—so thin that the softer base metal underlying the decorative chromium film "gives" under the file edge. The chromium is gouged in much the same way that a toothpick would press a groove into the tin-foil wrapper on a piece of cheese. Industrial chromium coatings are usually thick enough (or the base metal is hard enough) to prevent this "anvil" effect.

Actually, both types of chromium plate are inherently harder than the file, so that a file test merely indicates the thickness and not the hardness of chromium plate. Drs. C. G. Peters and Frederick Knoop, of the Bureau of Standards, demonstrated three years ago that hardness tests on plates thinner than one thousandth of an inch (0.001 inch) reflected the hardness of the base metal, whereas plates thicker than that were unaffected by this factor.

The most important difference between decorative and industrial chromium plates, then, is *thickness*. For decorative chromium plating a thickness of about one or two hundred-thousandths of an inch (0.00001 to 0.00002 inch — about 1/200th the thickness of a human hair) is generally used. Except for a few applications requiring plates approaching that thinness, industrial chromium plates run from one ten-thousandth to 25 thousandths of an inch thick (0.0001 to 0.025 inch). Good practice is to apply the thinnest coating that the hardness of the base metal will permit.

Because of their greater thicknesses, industrial chromium coatings take longer to apply, and this must be taken into consideration in the operation and control of the plating bath. Several processing factors not encountered in decorative plating, such as the avoidance of excess plating at corners and edges, the importance of good adherence to the base metal, and the finishing of the deposit to very precise dimensional tolerances, confront the plater who applies industrial chromium.

Engineers of United Chromium, Inc. (the company whose basic patents dominate the chromium-plating field) have made exhaustive surveys and tests of the technical properties of chromium plate. Examination of their results shows not only that chromium is superlative in many ways, but also that its combination of high hardness, corrosion resistance, wear resistance, resistance to heat, and frictional and surface properties is available in no other industrial material yet discovered or developed.

For example, the hardness of correctly produced bright industrial chromium plate is about 1000 to 1025 Brinell. This hardness is of the same degree as that of nitrided steel (one of the hardest engineering metals) or sintered tungsten carbide (the hardest type of cutting-tool material).

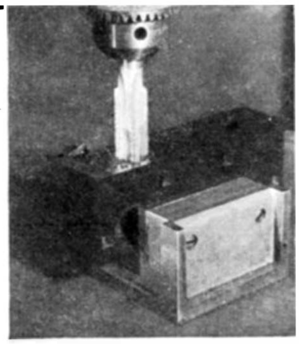
Several years ago the Worthington Pump and Machinery Corporation, curious about chromium plate's ability to serve as a bearing material in comparison to that of the usual bearing metals, made sliding friction tests on a number of shaft and bushing combinations. The standard bearing combination of steel on babbitt metal had a coefficient of friction of 0.20. When the babbitt was replaced with chrome-plated steel, the new combination ran much easier, with a coefficient of 0.16. The engineers who made these tests concluded that "chromium has the lowest coefficient of friction available in any of the structural metals." This conclusion has since been reached by other researchers.

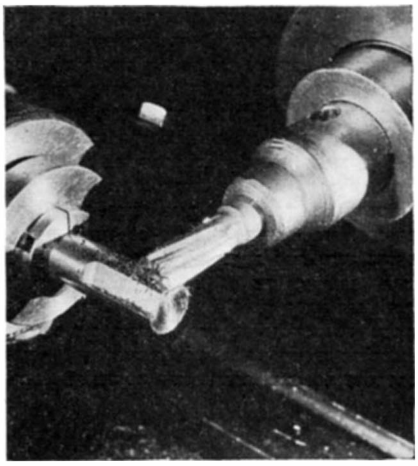
The third outstanding quality of electrodeposited chromium is its unusual resistance to corrosion and chemical attack. These characteristics are utilized in many familiar applications of chromium plating. Where so used, chromium plate is usually applied over intermediate deposits as, for instance, copper and nickel on steel or nickel alone on copper or brass. The function of the underlying deposit is to prevent the exposure of the basis metal through any pores that may exist in the layers of electrodeposited chrome. Properly plated articles are resistant to tarnish, rust, and corrosion, and thereby are of great value in prolonging the usefulness of the product to which they are applied.

Also important among its characteristics are chromium plate's amenability to use *and reuse,* as a "putting-on tool" (for adding metal where needed), its adapability to precision operations, its resistance to oxidation at high temperatures, its high melting point, and its relatively low cost from the engineering point of view.

Lest exaggerated conclusions be drawn from these facts, it is pointed out that chromium plate is not a cure-all or panacea. For example, it is not necessarily the best bearing metal in the world, since there is considerably more to bearing performance than just the coefficient of friction. It is certainly not the hardest engineering material one can find; and it is surpassed in corrosion resistance by a few (mostly noble) industrial metals. But it is just about the hardest material available which is also corrosion-resistant and "slippery," and its growing list of applications in special services stems from this unique combination of properties.

The long list of applications which chromium plate is finding in industry is exemplified by the plated tap (right) being used on a hard rubber part, the side milling cutter (below) in use on steel, and the twist drill (lower left)





The use of chromium plating as a "putting-on tool," for adding metal to surfaces that have been worn or mismachined undersize, is its major contribution to industry. Some typical instances of smart reclamation of off-size rejects by chrome-plating were recounted in detail in an article in the June 1941 issue of Scientific American, and little need be added here. Intricate parts, gages, tools, dies, and fixtures representing many hours of skilled tool work, much precious machine time, and important amounts of critical alloys are being saved from scrap piles everywhere by alert plating departments.

At one plant, plating thicknesses have run up to 40 thousandths of an inch (0.040 inch) and over 10,000 parts have been salvaged in the last few years. Many manufacturers who started using chromium plating for salvage work found the service life of the reclaimed parts so much improved that they now specify chromium plating as standard on these parts even when new.

In the field of new tools and parts, the applications of chromium plating may be simply divided into (a) cutting tools, (b) gages, dies, and molds, and (c) wear-resistant machinery parts. For industrial chromium plating the thinnest coatings are those applied to cutting tools, such as cutters, reamers, drills, taps, broaches, and so on. For applications like these, involving sharp edges or impact, deposits heavier than a few ten-thousandths of an inch tend to spall or chip, so that the practice is to hold the plating to thicknesses between five ten-thousandths and five hundred-thousandths of an inch (0.0005 and 0.00005 inch).

Mr. T. G. Coyle, technical director of United Chromium, Inc., explains in addition that the best plate thicknesses for tools used for cutting steel are different from those for cutting plastics or soft metals. He suggests this generalization: *The harder the material being cut, the thinner need be the chromium deposit.* Most of the benefit of chromium plate on cutting tools arises not so much from the extra hardness of the plated tool but from the lower coefficient of friction between the plate and the material being cut, whereby the chips slide off along the tool more easily.

The quantitative extent to which industrial chromium plating is providing a large part of the answer to the shortage of small cutting tools and tool-steel alloys by enormously extending their lives is indicated by the job records of many manufacturers. For example, at a Canadian plant (John Inglis Co., Ltd.) one tool, a 0.237-inch diameter reamer, would, when unplated, turn out 15 pieces before it had to be reground; after chromium plating, 75 pieces between grinds was a common figure (an increase of 400 percent) and, furthermore, the tool could be continually replated and re-used at its original size.

Reports on chromium-plated plug gages indicate life increases because of chromium plate ranging from seven to twenty times that of the unplated gage. On a few special gages, chromium plate has shown several hundred percent longer life than carbide tips—and that *is* an achievement!

According to Mr. Coyle, gages are generally finished with a chromium plate 0.001 to 0.015 inch thick. In some gaging operations, where tolerances are extremely small or the gage must have a sharp working edge, the chromium plate thickness should be much less than 0.001 inch—only of the order of 0.0001 to 0.0003 inch.

Since gages are sizing tools, dimensional precision is important. In cases where the thin deposits are used (and with some of the thicker, too), the gage may be plated directly to size with sufficient accuracy, but generally it is more practical to over-plate and then grind or lap back to size after plating.

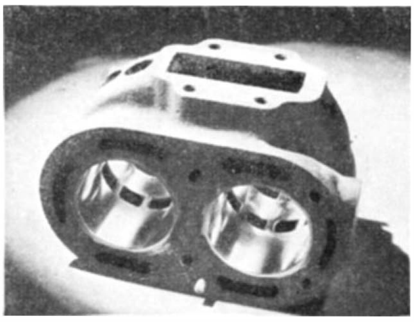
Chromium-plated dies and mandrels are almost universally employed for drawing seamless tubes of steel, stainless steel, brass, and aluminum. Tool-life increases of eight to ten times are reported, together with improved tube finishes.

A field that is very active at present and a potentially even busier one in the future for chromium is the plating of molding dies for plastics. Naval specifications now require it on molds for Navy Department parts and the largest fabricators have also swung over to plated molds. The plate thicknesses run from 0.001 to 0.005 inch.

The plastic or rubber parts made in plated dies are smoother; sticking, fouling, and pin breakage are eliminated; and the flow of the compound along the die walls is facilitated. For a given amount of wear, the chromium surface produces 10 to 15 times the output of the hardened (unplated) steel surface in some shops. Chromium-plated dies are also used in powder metallurgy, where die problems have been traditionally acute.

Porous chromium is potentially important enough to receive special attention here. Today it is doing yeoman service as the surface on countless Diesel engine cylinder bores aboard ship and elsewhere. These important Diesel applications have been pioneered by Mr. Henrik Van der Horst, a former Hollander who spent years in developing this solution to a specific problem—the wear of cylinder bores, piston rings, and ring gaps in Diesel engines, especially two-stroke engines.

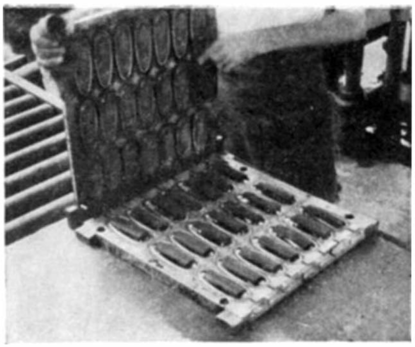
Originally the cylinder bores were merely plated with dense bright chromium, and general improvement in performance was obtained. But



Chromium plated cylinder bores

some bores would score, even after honing to a high polish, until one day someone observed that the chromium surfaces that did not score were slightly pitted. It then became clear that for oil-film bearing applications like this, not only hardness but a *rough* surface was necessary to retain the oil on the normally non-absorbent chromium surface, and research was directed to the development of a uniformly porous hard-chromium layer.

Cylinder bores treated in this way wear away at a much lower rate than ordinary cast-iron bores, will outlast alloy cast-iron bores by seven times and nitrided bores by three times. In



Hard-rubber molding dies are plated

Diesel-operated ships, for example, this means fewer delays and layovers while cylinders are replaced, relined, or rebored or rings replaced, and even making trips that might normally be cancelled because replacement parts could not be obtained.

The use of porous chromium plate on internal combustion engines generally and for other oil-retaining bearing surfaces is now receiving the most widespread attention, with both the Van der Horst Corp. of America, Inc. and United Chromium, Inc. conducting research on processes and applications.

The exigencies of war have brought to industry sudden recognition of the value of chromium plate as an engineering material, and the process and its applications have developed with unbelievable rapidity. When peace returns, the pressure for salvage will be off, but many companies—the smarter ones—will continue the reclamation practices they found so helpful during the war.

Quite apart from salvage, we may confidently expect the use of chromium plate on such new parts and tools as drawing and extruding dies, molds, burnishing broaches, hydraulic equipment parts, bearings, and so on, to continue to expand, because for many of these it will be simply intelligent design and economics to use it. Those applications involving stainless steels, light metals, plastics, powder metallurgy processes, and engine parts should be especially important in the years to come. Of all the present-day applications of chrome-plating, the use of porous chromium as a hard, wear-resistant oil-retaining surface for Diesel cylinders and rings, gas-engine cylinders and pistons, *and hundreds of other parts not yet exploited* may be ultimately the most important.

LEAD-ALLOY COATING

For Copper Wire, Satisfactorily Replaces Scarce Tin

Much of the wire normally used for electrical conductors in normal times was coated with pure tin to facilitate soldering of joints and connections and to protect the underlying copper and its rubber insulation from reacting with each other. The shortage of tin, however, impelled a search for materials that comply with the WPB order limiting the tin content of copper-conductor coatings to 12 percent and which will perform satisfactorily.

The requirements for such coatings are amenability to fast soldering, good resistance to abrasion, excellent anti-friction properties, and resistance to corrosion by sulphur and by rubber chemicals.

Of all the possible substitutes tested by Anaconda Wire and Cable Company (including lead-base alloys of less than 5 percent tin), the only one that approached the desired properties was an alloy of lead to which small amounts of cadmium, tin, and antimony are added. Average analyses of coatings from the new alloy show 5.23 tin, 1.17 cadmium, 0.30 antimony, and 93.30 percent lead.

The alloy has been in continuous use (under wraps) for 16 months, during which 500 million pounds of wire has been coated, stranded, and insulated with satisfactory results. Statistical analysis of the substitution shows that approximately 87 percent of the tin previously consumed for this application is being saved by the use of the new alloy. At Anaconda this means a saving of about 3500 pounds of tin per month.

BERYLLIUM-COPPER

Improved for Many Uses by New Heat Treatment

Expanded wartime applications of beryllium-copper have taught materials engineers much about the properties that are best for individual applications and about the methods of heat treatment best able to provide these properties.

Beryllium-copper's greatest contribution today is in the field of aircraft, instrument, and electrical springs, where its combination of exceptional strength, corrosion resistance, high endurance, flexural and torsional strengths, and susceptibility to hardening *after* forming make it a nearly ideal material.

Recent intensive studies have shown, however, that peak properties cannot be obtained by the standardized heat treatment usually recomended, that the work and treatment given the beryllium-copper at the mill that sells it to the spring fabricator profoundly influence the results the latter obtains with it, and that each lot of beryllium-copper for springs must be individually tested and treated by the spring maker if the full value of the metal is to be obtained.

The heat treatments used will thus be individually different for each lot, but the new data show that the practice of hardening the annealed and formed springs by heating for a given time between 500 and 600 degrees, Fahrenheit, should be changed to a shorter time at higher temperatures—between 600 and 700 degrees. Springs processed by the new schedules have much better "drift" properties (drift is the tendency to become permanently elongated by minute amounts through stress *below* the elastic limit at room temperatures) and are generally superior.

Conducted by JAMES M. CROWE

Synthetic Rubber Today

Enough Can Now be Told About Synthetic Rubber to Indicate that the Problem of Replacing Natural Rubber in Many Vital Applications Will be Solved Satisfactorily. A Resume of the Most Important Synthetics, Their Composition and Qualities, and Raw Materials Used

AT THE END of 1941 the total installed capacity for production of synthetic rubbers in the United States amounted to only about 20,000 tons. Then came Pearl Harbor and the war-necessitated miracle of increasing this synthetic capacity to nearly a million tons by the end of 1943.

Generally speaking, the synthetic rubber-like materials on which the United States will depend for its rubber during the present war may be divided into a number of types. It would require volumes to tell the detailed story of the manufacturing processes and properties of these many materials, and even then it would probably be inaccurate. Specific operating details have never been made public and the technology is changing so rapidly under the stimulus of all-out research that methods are changing and improving every day. However, the following brief and general descriptions, derived from a Bureau of Mines survey, will explain the nature of the more important of the synthetics, the way they are produced, and their general applications.

BUNA S: Copolymerized butadiene and styrene, synthesized by copolymerization in aqueous emulsion.

Buna S has been made in large quantities in Germany since 1936 as a general substitute for rubber, particularly in automobile tires. A small amount was made in this country prior to the war. Of all the various types of synthetic rubber that have been developed, each with special advantages, the Buna S type seemed best for rubber's major uses, and could most easily be fabricated with existing equipment. The government rubber program was, therefore, largely concentrated on this type. Buna S, more recently designated GR-S, is now manufactured by a number of companies on a large scale for use in tires and as a general substitute for natural rubber. Out of the 850,000 tons annual capacity undertaken by the government rubber program, 735,000 tons or about 86 percent is Buna S.

The raw materials used in Buna S are butadiene and styrene. The butadiene may be made by many methods from a number of basic materials, present commercial sources of butadiene being petroleum and petroleum gases, coal or coke and limestone, ethyl alcohol, and butylene glycol made by special process of fermentation of grain.

Much of the early confusion about synthetic rubber arose from a lack of appreciation of the fact that Buna S is exactly the same product whether made from butadiene derived from oil, grain, coal, or whatever source.

Styrene, the second requirement for manufacture of Buna S, has been manufactured for some time for use in the plastics industry; hence, the principles involved in its production were quite well known. The most common method consists of processing ethyl benzene produced from benzene and ethylene or ethyl alcohol. Styrene may also be produced by high-temperature cracking of petroleum.

In general, the properties of Buna S are similar to those of natural rubber, and the swelling characteristics in gasoline and mineral oil are but little better than those of natural rubber. Water absorption is only 65 percent that of natural rubber, and aging qualities are considered superior. It is useful for coverings in the cable industry because of the last-named qualities.

PERBUNAN (formerly Buna N): Copolymerized butadiene and acrylonitrile in an aqueous emulsion. The butadiene is obtained from the same sources as given above, while the acrylonitrile is made by treating ethylene with hypochlorous acid to give ethylene chlorohydrin, which reacts with sodium cyanide to give hydracrylic nitrile, from which acrylonitrile is obtained by dehydration.

A primary property of Perbunan is its resistance to the action of gasoline, petroleum, and aliphatic hydrocarbons. However, it is soluble in aromatic and chlorinated hydrocarbons such as benzol, toluol, solvent naphtha, di- and trichlorethylene, and in certain ketones.

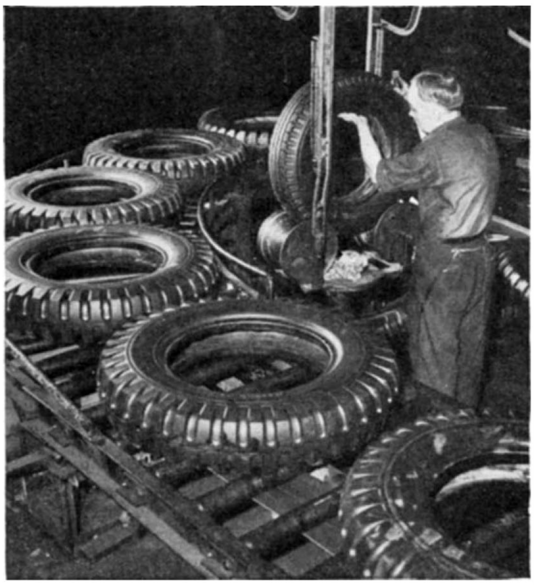
Aging qualities and resistance to ozone are said to be superior to those of natural rubber, but elasticity, rebound, and electrical properties are poorer. Because of its poor electrical properties, Perbunan is not used as electrical insulation. In heat resistance and abrasion resistance it surpasses natural rubber and is less than half as permeable to air and gases. Hard compounds made from Perbunan have high softening points and superior resistance to many solvents.

Perbunan finds greatest use where its oil-resistant qualities are needed —oil-resistant packing rings, gaskets, printing rolls, gasoline hose, hose for spraying paint, cable covers, conveyor belts, and the like. Although Perbunan tire tread compounds are said to be equal or superior to the best rubber tread compounds, its use in tires is not of commercial importance, as other synthetics easier to process and fabricate are considered economically more suitable for that purpose.

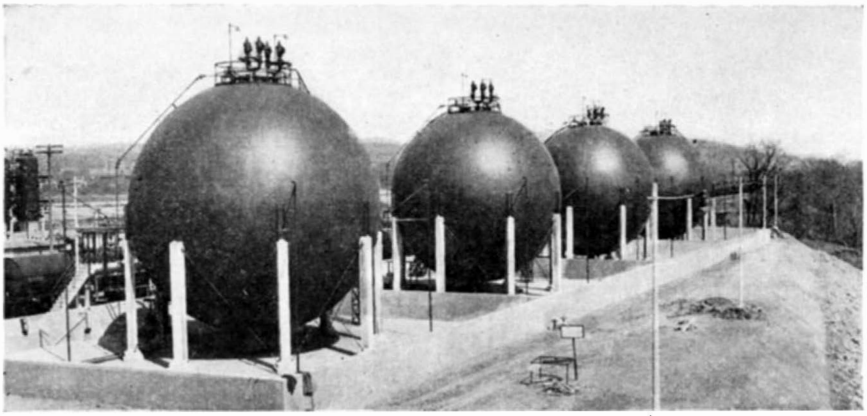
Perbunan Extra is similar to Perbunan except that the acrylonitrile content is greater. It is easier to process, more resistant to oil.

HYCAR "O R" (AMERIPOL): Butadiene copolymer, reported to be a copolymer of butadiene and acrylonitrile similar to Perbunan. Two distinct types are being made. The raw materials are butadiene and acrylonitule. (See Buna S for butadiene sources and Perbunan for acrylonitrile).

Properties of Ameripol, such as tensile strength and elasticity, are said to vary over a wide range according to the method of compounding. Good heat and abrasion resistance are claimed, and superior resistance to mineral, animal, and vegetable oils and fats, to oxidizing effects of metallic soaps used as driers in paints and inks, to all petroleum products, and to benzene, alcohol, water, and carbon tetrachloride, although it is badly swollen by acetone. Its age resistance is superior to that of natural rubber and its resistance to acids and alkalies is about the same. Elasticity, tear resistance, and rebound are lower than for similarly compounded natural rubber. Hardness may be varied over a wide range. It becomes stiffer than natural rubber at subfreezing temperatures but is reported to be still flexible at —50° Centigrade. Resistance to oxidation and decomposition when exposed to heat is said to be



Synthetic rubber tires for the armed forces



Butadiene storage tanks at a Carbide and Carbon Chemicals Corporation plant

excellent, and it is less permeable to air and gases than is natural rubber.

Oil-resistant products made from Ameripol include gasoline hose, automobile and airplane parts, packing joints and valves, lining for bullet-proof gasoline tanks, printing rollers, and the like. Tires of Ameripol are said to be slightly superior to tires made of natural rubber compounds in abrasive resistance, and far superior in the presence of oils and high temperatures.

The synthetic is used to produce a hard rubber compound, "Ebonar," which is said to have an outstanding advantage over hard natural rubber in that a higher softening point is obtainable.

CHEMIGUM: Butadiene copolymer, said to be a copolymer of butadiene and acrylonitrile similar to Perbunan.

A Buna-type synthetic rubber, Chemigum is tough and is equal or superior to natural rubber in strength, aging resistance, and resistance to sunlight. It is much less soluble in conventional rubber solvents than natural rubber, and its oil resistance makes it suitable for use in gasoline hose and the like. Tires made of Chemigum are said to give performance equal to or exceeding natural rubber tires.

NEOPRENE (formerly DUPRENE): Polymerized chloroprene made by polymerization of chloroprene in emulsion under carefully controlled conditions. Raw material is calcium carbide, made from lime and coke in a high-temperature electric furnace, which gives acetylene when treated with water. Vinylacetylene, formed by polymerization of two molecules of acetylene, is treated with hydrochloric acid to give chloroprene. The physical qualities of Neoprene may be modified over a wide range by the proper choice of pigments, accelerators, anti-oxidants, and so on.

Neoprene is made in several types, Neoprene G being a new, improved, relatively odor-free type which is thermoplastic and is formed, like rubber, by calendaring, extruding, and molding at high temperatures.

The vulcanized product is resistant to oils, and although virtually all animal, vegetable, or mineral oils cause it to swell somewhat, it usually retains its properties better than rubber. It is slightly less elastic than rubber but is more heat-resistant and resists sunlight better. It has approximately the same tensile strength as has similarly compounded rubber. The abrasion resistance of Neoprene tire treads is said to be about equal to that of the best rubber tire-tread compounds. Neoprene and rubber show about equal abrasion resistance when dry, but Neoprene is many times more resistant to abrasion after having been soaked in oil.

Neoprene is used for tank linings; reaction vessels; conveyor belts; gaskets; hose for oils, solvents, and gases such as chlorine; clothing for acid protection; laboratory tubing; and for similar purposes.

VISTANEX: Polymerized isobutylene, made by polymerizing isobutylene at low temperatures with catalysts of an acidic nature, such as titanium tetrachloride, boron fluoride, and aluminum chloride. Isobutylene is present in large quantities in gases from refinery cracking operations, and may be made by dehydrogenation of isobutane, which is obtained from natural gases or from isomerization of normal butane.

Vistanex possesses unique qualities, owing to its lack of unsaturation. It exhibits extreme resistance to ozone, acids, alkalies, and corrosive salts and has excellent aging properties, especially at high temperatures. Its water-absorption and vapor-permeability properties are extremely low. It is resistant to most vegetable and animal fats, oils, and greases, and is insoluble in alcohols, esters, ketones, and most organic solvents containing oxygen; but it is soluble in petroleum and coal-tar solvents and in some chlorinated solvents. It has excellent electrical properties. It is less thermoplastic, and the degradation or breakdown by mechanical milling or mixing is less than for natural rubber.

Vistanex is used in the manufacture of cable sheathing, acid-resistant linings, electrical insulation, adhesives, artificial leather, and the like. It may be compounded with natural rubber in certain proportions to give a curable product useful in steam hose, conveyor-belt covers, cable coverings, and other products resistant to aging or chemical action.

BUTYL: Copolymer of a butene and a diolefin, produced by low temperature copolymerization of isobutylene and a small amount of butadiene or other diolefin. Isobutylene is procured from petroleum by cracking.

Butyl rubber is outstanding in that it possesses only 1 or 2 percent of the available unsaturation of natural rubber, which is just enough for vulcanization. This lack of unsaturation gives butyl rubber unusual properties in aging resistance and in stability in the presence of ozone. It swells like natural rubber in petroleum and coal-tar solvents but does not swell in most vegetable and animal fats and oils. It is resistant to acids, including sulfuric and nitric, has low water absorption, high heat resistance, and excellent flex resistance, and is highly impermeable to air and gases such as hydrogen, helium, and carbon dioxide. Its rebound is low at room temperature but high at high temperatures. Electric properties are said to be such as to make it outstanding for cable insulation.

Butyl rubber is said to be satisfactory for inner tubes, as it holds air longer than does natural rubber and is considered superior to certain other synthetic rubbers for this purpose, although some difficulties have been experienced. So far, automobile tires made of butyl rubber have shown a life about 50 percent as great as that of natural-rubber tires if used at speeds under 40 miles an hour. Besides its use in tires and tubes, it is recommended for use in fire and steam hose, molded goods, tank linings, conveyor belts, and in general replacement of natural rubber.

FLEXON is similar to butyl rubber except that it is produced at different temperature in an open vessel. It usually has qualities inferior to butyl.

THIOKOL: Organic polysulfide obtained by a reaction between organic dihalide and alkali polysulfide.

The raw materials used in Thiokol depend on the finished type. Ethylene dichloride and sodium tetrasulfide give Thiokol A; dichloroethyl ether and sodium tetrasulfide give Thiokol B; and so on. The sources of these raw materials are organic compounds which may be obtained from petroleum products, chlorinated by the use of chlorine obtained from salt. The sulfides are made from sulfur and alkalies.

Thiokol has been made in several types and from several primary materials. A variety of products, some of which are rubber-like and some of which are not, can be made by varying the kind of polysulfide and hydrocarbon. Some of the products are used in the plastics industry and some as a rubber substitute. The rubber-like types are soft and plastic and can be worked on a rubber mill and reinforced and modified by the addition of compounding agents just as with natural rubber. They are particularly resistant to organic solvents.

Thiokol is not suitable for tire treads, although a new type (N) is said to be suitable for recapping tires. In general, Thiokol may be used where high resilience, tensile strength, and resistance to heat are not important, but where good aging characteristics, resistance to ozone and solvents, and flexibility are required. It is used in the automotive industry for coating paper gaskets, where it flows under heat and pressure into tool marks and imperfections to make a perfect oil seal. It is used also in the manufacture of gasoline and paint-spray hose, printers' blankets, rubber printing plates, and cable coverings.

THIOKOL R D: Copolymer obtained from butadiene and acrylonitrile. In the raw state it is a tough, resilient, amber-colored, solid with excellent resistance to gasoline, oil, and other solvents. It has high tensile strength, up to 3000 pounds per square inch, and good abrasion resistance, comparable to natural rubber.

KOROSEAL AND KOROGEL: Plasticized polymerized vinyl chloride. Vinyl chloride is produced commercially by any of three methods: catalytic combination of acetylene and hydrogen chloride; chlorination of ethlyene to ethylene dichloride and partial dehydrohalogenation by treatment with alcoholic caustic; or by vapor-cracking ethylene dichloride.

The term "Koroseal" refers to a broad class of compositions having properties varying from those of hard rubber to those of a jellied cement. Korogel is highly plasticized Koroseal, and Korolac is a solution of Koroseal.

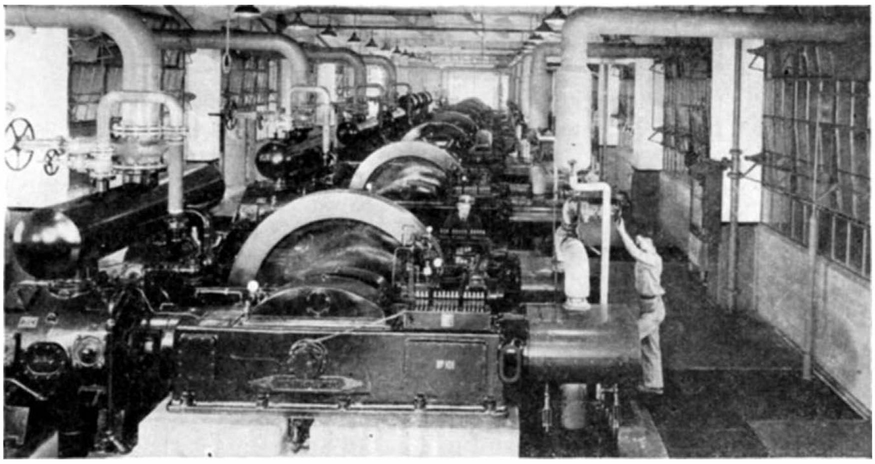
The physical and chemical properties of Koroseal may be varied over a wide range by the choice of plasticizer. With proper plasticizer it can be made transparent. The tensile strength varies from 1000 to 9000 pounds per square inch; flexing life, if used alone, is ten times that of natural rubber; tearing strength is equal to or slightly exceeds that of the best rubber compounds; and at atmospheric temperature resistance to abrasion is better than that of rubber. However, Koroseal is unsuitable for the manufacture of automobile tires, as it undergoes plastic flow at high temperatures.

The harder types of Koroseal are resistant to virtually all materials except organic compounds containing the nitro or chlorine groups, aliphatic or aromatic ketones, aromatic amino compounds, lacquer solvents, or acetic anhydride. Koroseal is resistant to corrosive chemicals, acids, alkalies, and water; it is not affected by sunlight, aging, oxygen, or ozone, and it is very superior in resistance to gas diffusion.

Koroseal is used in the manufacture of process equipment for chemical and allied industries, in pipe-line coating materials, balloon cloth, chemical tubing, vacuum and gas materials, electrical insulation, protective paints, belting, gaskets and packing, clothing and waterproof cloth such as wraps and shower curtains, upholstery, and for special uses in the cable and textile industries.

FLAMENOL: Plasticized polymerized vinyl chloride, is described as a synthetic compound resembling rubber, which serves both as an insulation and a finish for wire and cable. Its properties are said to include high dielectric strength, toughness, mechanical strength, stability in sunlight and oxygen, stability to ozone and oxidizing chemicals and to oils, solvents, acids, and alkalies, and resistance to flame and moisture.

POST-WAR RUBBER: The above lengthly but incomplete list presents an imposing array and still there are others and newer elastomers which have been announced, but about which there is little available information. All in all it seems that the country can rest assured that the rubber problem is being met.



Compressors used in a butadiene production unit

With this assurance many people in government and industry are turning their thoughts to rubber after the war. There are many important political and economic considerations which may develop natural rubber *vs.* synthetic elastomers into a major controversy, but ultimately the principles of supply and demand, of price and quality, that have influenced so many choices between products, will decide this issue.

One thing is certain. It is never safe to make predictions where a chemist is concerned. His ingeniousness and persistance in working with molecules and the fundamental laws of nature have often upset the best laid plans. Based on progress to date, chemists believe that there will come synthetic compositions which excel natural rubber in wear, resistance to deterioration, and other properties. In fact, many of these objectives have already been reached.

This does not mean that natural rubber cannot be improved. It undoubtedly will be. But the fact remains that the essential need for crude rubber, based solely upon superiority of its properties, is almost a thing of the past. The choice in a free world market will largely depend on cost and quality together.

It is generally believed that the price of synthetic elastomers might go down to between 10 and 15 cents per pound. Prices of natural rubber have fluctuated widely in the past. In 1910 an all-time high of $3.12 was reached. After World War I it dropped to 11¾ cents. Then a production control system was organized in the Far East and the price went to $1.21 in 1925. In 1932, during the depression, it dropped to 2.625 cents per pound. It might be said that the price of natural rubber ordinarily oculd be taken at 15 cents per pound. Prior to World War II it was fixed at 22½.

Some post-war plans advocate a return to the importation of rubber from its former sources and the development of new natural sources in this hemisphere. Fundamentally their argument is that this would provide jobs for the native populations and increase their standards of living. If this is done it is logical that their wages would go up and if so it is a question whether the price of natural rubber, which is so dependent on cheap labor, could be kept lower than synthetic. Only time and technology can answer these questions.

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PENICILLIN

New Chemotherapeutic Agent Holds Great Promise

A new antibacterial substance, penicillin, has joined the ranks of the "miracle drugs." Clinical tests of the new material give good reason for belief that it is superior to any of the sulfonamides in the treatment of *Staphylococcus aureous* infections, including acute and chronic osteomyelitis, cellulitis, carbuncles of the lip and face, pneumonia and empyema, infected wounds and burns. Preliminary tests on wounds and infections of soldiers returned from the battlefronts have been so encouraging that the tests are going forward on a broad scale.

In this work many difficulties are encountered. They arise chiefly from the facts that the mold, *Penicillium notatum,* from which penicillin is obtained, produces only tiny amounts of anti-bacterial substances after a long period of growth in a culture medium that must be very carefully protected and controlled. According to a recent report, a yield of as much as one gram of purified penicillin from 20 liters of culture fluid would be an excellent result.

The chemical structure of the material is being intensively sought after. No conclusive results have yet been obtained but there are indications that the structure resembles that of a large class of aromatic or coal-tar chemicals. As soon as this chemical structure is determined, methods of synthesis and large-scale production will undoubtedly be developed.

Conducted by ALEXANDER KLEMIN

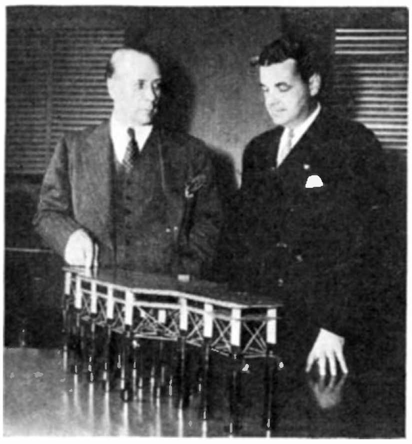
SINCE the first direct crossing of the Atlantic Ocean by airplane, made more than 20 years ago by Alcock and Brown, flying across the North Atlantic has been made commonplace by the Clippers of Pan-American Airways and American Export Airlines, the huge flying boats of the British Imperial Airways, and the cargo planes of the Air Transport Command. man-made islands to be moored in the North Atlantic for use as plane refueling stations. Invented by Edward R. Armstrong as far back as 1915, and lately developed and sponsored by such important corporations as the Sun Shipbuilding and Dry Dock Company, United States Steel Corporation, Worth Steel Company, Lukens Steel Company, Belmont Iron Works, General Electric

Floating Airports in Mid-Ocean

Reported Many Years Ago in these Pages, the Armstrong Seadrome is Now Assuming Added Importance in the Scheme of Things to Come in Aviation. Based on Sound Engineering Principles, the Seadrome Will Make Possible Over-Ocean Air Transportation with Land Type Planes

Bombers and even single-seater fighters are now being regularly ferried across the ocean, the fighters with the aid of droppable gasoline tanks to supply sufficient fuel for the crossing.

Most of this flying involves long jumps, sometimes of the order of 2000 miles; and for very fast de luxe passenger service of the future it will not



Armstrong (left) and Monro, with a model of the floating island airport

be surprising to see non-stop operation between New York and London or Paris.

For less expensive passenger service, however, and for carrying air cargo or express, such long hops involve difficulties. A tremendous amount of fuel has to be carried because, in addition to the actual flight length, allowance has to be made for head winds, for possible loss of direction, for instrument approach, and for flying to an alternate airport. With high fuel loads, the actual payload (that is, passengers and cargo) is reduced to a small fraction of the gross weight of the airplane.

It is to meet this fundamental drawback of the airplane that there has once more come to light the idea of Company, and John A. Roebling Sons Company, the Armstrong Seadrome has been patiently developed, step by step, and has now reached a point where far-sighted and hard-headed C. Bedell Monro, President of Pennsylvania-Central Airlines, has filed an application with the Civil Aeronautics Board for permission to connect eastern cities of the United States with Seadromes in the North Atlantic and thence with ports of air commerce to be designated by the Civil Aeronautics Board.

The sponsors of the Seadrome system state that these new bases will be made available to all companies and all nations that qualify. This is done so that the progress of post-war aviation will not be impeded and so that America can truly be said to be in a position of collaborator and not merely of competitor in trans-oceanic air travel.

Mr. Armstrong's long struggle for recognition of the Seadrome epitomizes the history of invention. During the long years of Seadrome development he has met every rebuff philosophically and has, with great continuity of purpose, kept on making new designs and new models.

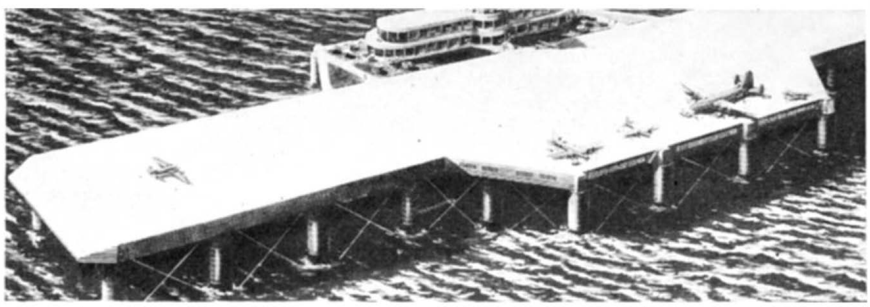
The islands of steel, known as Seadromes, consist of a floating platform 70 feet above the ocean, with buoyant elements so far down as to give a draft of 160 to 180 feet. No matter how rough the ocean may be, these elements make the Seadrome as steady as the mainland itself. Experiments made in a test basin with artificially created waves have given ample proof of the accuracy of this statement. To those who immediately visualize a huge steamship being tossed about in waves, the idea at first appears fantastic. Yet it is based upon sound principles of physics and extensive study of wave motion.

The ocean is destructive only when it is opposed, as near the coast. In mid-Atlantic, vast rollers become harmless, particularly when allowed to travel through an open truss work as in the Seadrome structure. But to explain why the Seadrome remains level, despite ocean roughness we must go to other facts of natural philosophy. The trochoidal wave of the surface of the sea has its companion form below, but the height of the wave formation decreases rapidly below the surface. At 30 feet below, the wave motion is scarcely perceptible. Therefore, the buoyancy elements and the ballast elements of the Seadrome are placed well below the surface. The diagram shows a 1500 foot Seadrome in waves 600 feet in length and 30 feet in height. As the waves pass, the buoyancy varies slightly from flotation element to flotation element, but the sum of the buoyancies remain constant. Since the total buoyancy is constant, the Seadrome neither rises nor falls with the waves.

Because of this constancy of buoyancy, because the wave motion almost disappears at depth, and because the power of the ocean is not challenged, the design of the Seadrome is reduced to a problem in civil engineering not dissimilar to that of bridge construction. The design of the Seadrome now under construction has been approved with a *A-1 rating by the American Bureau of Shipping.

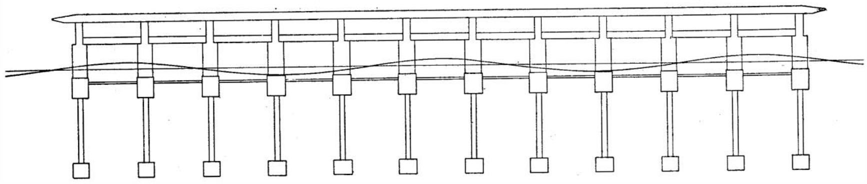
THE FLOATING airport will have a total displacement of over 100,000 tons and its landing deck will be 70 feet above sea level. The structure will be 3550 feet in length, 400 feet wide at the center, and 280 feet wide at the ends—ample dimensions for taking care of large transports and capable of handling with ease an airplane of some 100,000 pounds gross weight, or possibly more. Auxiliary power sources and six electrically actuated propulsion units will deliver a thrust of 300,000 pounds—sufficient to maintain the Seadrome on station, even if the anchorage gear should fail.

The deck will be supported by 72 buoyancy tanks connected to it by



Platform of the Seadrome, showing the hotel and parking facilities means of streamlined steel and iron columns. The whole will form a deep truss composed of tubular struts and steel cable ties encased in iron pipes. Iron will be used because research has shown that iron, while not as strong as steel, provides greater protection against corrosion. The tanks will be arranged symmetrically in three rows of 24 each, with longitudinal spacing of 150 feet. The lower columns extend to about 110 feet below the buoyancy tanks to support the ballast tanks. These contain sufficient ballast to lower the center of gravity of the structure to about eight feet below the center of buoyancy, another reason for the extreme stability of the structure.

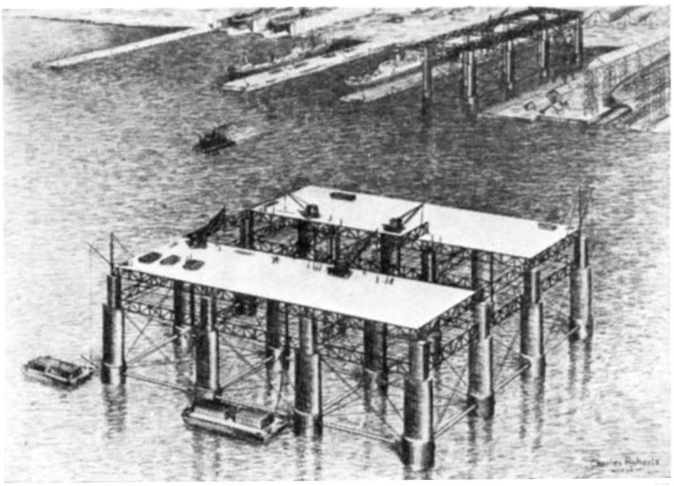
All exposed parts of the Seadrome in the region of the water line and above it will be of streamlined shape to reduce head resistance to a minimum. The lower columns will be circular in cross-section so that they may be uni-directional in water currents.



How a 1500-foot Seadrome would remain level in 600- by 30-foot waves

The deep-sea draft of the Seadrome on station duty will be 165 feet. Obviously such great draft precludes erection close to the shore. Therefore, in order to make construction possible in shallow water, the ballast tanks are designed to telescope into the streamlined upper columns during erection. Decks and bulkheads will divide the tanks into 12 watertight compartments. There will be bilge pumps and air pumps, as in a steamship.

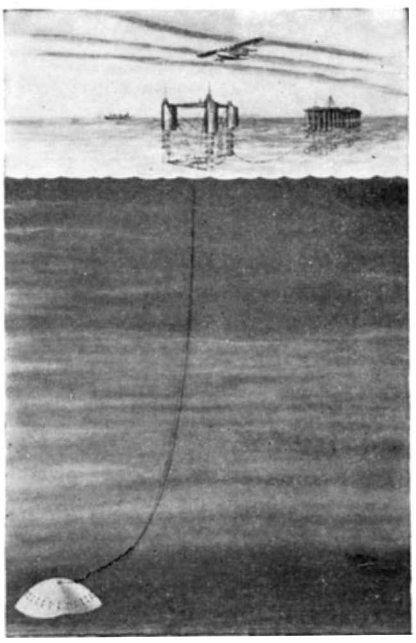
The Seadrome will be able to develop some forward speed, as previously stated, and its six screws will head it into the wind, as required for airplane operation, making a 90 degree turn in from 10 to 15 minutes. With this built-in means of propulsion, the problem of towing the Seadrome into position should be a relatively simple one. But to those who know how difficult it is to anchor even a lightship of 1000 tons in relatively shallow water, and how frequently lightships tear from their moorings, it may at first appear impossible to anchor a structure of 100,000 tons in the deep waters of the Atlantic, for if a ship of this size were to be moored in mid-ocean, wind and wave would indeed make the task impossible. But the Seadrome will not pitch, roll, or heave at it's anchor, and, because of its constant buoyancy, the open-work structure will offer the least resistance to the motion of the water, while the upper above-water structure is streamlined. As a result, the natural forces acting on the Seadrome are reduced to a minimum.



The Seadrome will be built in sections, with the ballast tanks telescoped into upper columns, and then towed to sea

It is, however, necessary to guard against air forces reaching a velocity as high as 70 miles an hour. From Seadrome tests made in the New York University wind tunnel and carried out by the writer of this article, a total anchorage pull of only 600,000 pounds is anticipated. With a factor of safety of 3½ included in the stress total, this would require the unheard-of wind speed of 140 miles an hour to break a Seadrome loose from its anchorage.

Yet even 600,000 pounds is no small pull. The Seadrome is to be anchored in mid-Atlantic where the depth of the ocean may be from two to three miles. It becomes impossible to use link chain, such as is ordinarily used with ships. The very best forged alloy steel chains would break from their own weight before they reached the bottom of the ocean at approximately 13,000 feet. Suspension bridge cables, on the other hand, have ample strength to reach a depth of 60,000 feet, which is very considerably beyond the distance to the bottom of the deepest ocean. But cable must not be allowed to rub on the ocean bottom. For this reason, the anchorage cables will be slightly shorter than required for a given mooring and then will be extended at their lower ends by forged alloy steel chains which, in turn, will be attached to the anchor. The anchor chains then will take up the wear and tear on the bottom. They should be able to withstand this for some 20 to 30 years.



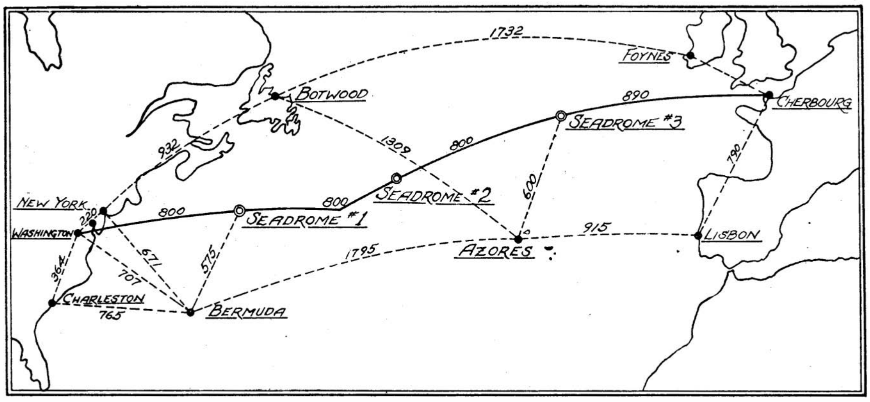
How the anchors of the Seadrome will rest on the bottom and hold the steel structure in place by means of bridge cables, with chains at lower end

The Seadrome anchors, which function by friction, must weigh more than 1000 tons each. They will be equipped with flotation chambers and so designed as to be built on a shipway, launched when completed, and then towed to position and sunk.

The facilities and equipment of the Seadrome, though placed in unconventional surroundings, are to be quite conventional in character. There will be a luxurious hotel, located at the side of the main platform so as not to interfere with the operation of aircraft. There will be ample arrangements for refueling and servicing of aircraft. A complete radio station and an equally complete weather bureau will be located on the structure. In general, the Seadrome will be a combination of an airport terminal and a luxurious summer sea hotel. It should be fascinating to spend a brief vacation in mid-Atlantic.

It is of interest to study the sketch map of the North Atlantic. The Seadromes will be moored 800 nautical miles apart and will be out of the region of fog and ice. Compare this distance with that between Botwood, in Newfoundland, and Foynes, in Ireland, which is 1732 nautical miles, and that between Bermuda and the Azores, which is 1795 miles. To fly the Seadrome route from Washington to Cherbourg means only 3200 miles in four hops of 800 miles each. Alternatively, Charleston to Bermuda is 765 miles, Bermuda to the Azores 1795 miles, the Azores to Lisbon 915 miles, and Lisbon to Cherbourg 798 miles, giving a grand total of 4273 nautical miles.

We cannot here enter into a detailed technical discussion of the economic advantages of the Seadrome, but the essence is as follows: An airplane weighing 25,000 pounds, undertaking a non-stop flight of some 500 miles, can carry a payload of 5000 pounds at a cost of 10 to 12 cents per ton mile. If, however, the length of the trip non-stop is 1500 miles, the payload may thereby be cut to 2000 pounds and the



Non-stop, island-stop, and Seadrome routes across the Atlantic

cost per ton mile then becomes 25 to 30 cents, which is prohibitive.

It is quite true that much larger airplanes, machines equipped with four 2000-horsepower engines and with a gross weight of around 100,000 pounds, can carry a larger percentage of payload, undertake longer trips, and have lower direct flying cost per ton mile. Nevertheless, even for the largest and best cargo airplane, the principle remains the same. The longer the non-stop flight, the less the payload, and the more costly the operation.

For very fast, de luxe traffic across the Atlantic, non-stop flight is feasible. The post-war business man of vast responsibilities, who wishes to spend a day in London and come back with minimum loss of time, will fly on a fast airplane which will bring him to Europe non-stop in a matter of 12 hours or so. The fare may be $500 or more, but cost will be of small importance. Such a fare would be out of the question, however, for the ordinary traveler or vacationist, but by reducing flight length and decreasing cost per ton mile, the Seadrome would make it possible to charge as little as $150 for a one-way ticket to Europe. An immense increase in air passenger travel would follow.

Again, instead of paying 60 cents for an air mail letter to England, we would pay 5 or 10 cents at most. An enormous increase in air mail would follow.

For freight and cargo, the steamship will probably remain supreme for many years to come. Where costs per ton mile are counted in cents for the airplane, they are counted only in mills per ton mile for the steamship. No aircraft, even with the use of Seadrome facilities, can begin to equal the cargo-carrying capacity of a large steamship. But as airplane operational costs go down, the possibility of increasing the amount of some classes of air express is clearly indicated.

The cost of constructing a Seadrome and getting it on station is expected to be around $12,500,000. Operating costs for three seadromes would be approximately $500,000 annually, and maintenance costs should not be high.

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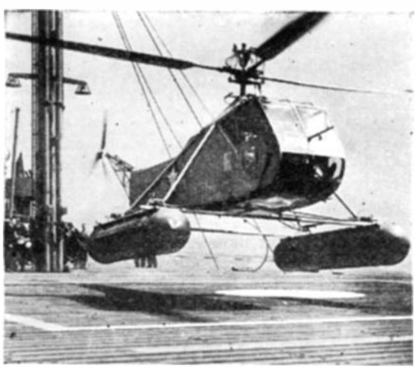
ANTI-SUB HELICOPTERS

Have Demonstrated Ability to Use Ship's Deck for Landings

SEVERAL years ago the use of helicopters for convoy work was advocated in Scientific American. Now the remarkable accompanying photograph shows the landing of a Sikorsky helicopter on the deck of a Maritime Commission tanker, with the craft hovering over the deck just before landing. In the process of the trials, the rotating wing aircraft made 24 landings and take-offs from the deck of the tanker. This was the first time that a helicopter had ever been landed on or flown from a ship deck, and the first time that there had been performed a ship-to-ship ferry flight by helicopter. The take-off space on the deck of the tanker was only 78 by 48 feet, closed in fore and aft by deck housing superstructure and mast. Flotation equipment on the helicopter made it possible to take off and land on water as well as on board the ship and the Sikorsky helicopter showed its usual flexibility and precision. In the opinion of the War Department, the advisability of using the helicopter as a weapon against the submarine has been fully demonstrated.



A helicopter lands on deck

ENGINE MATERIALS

Can be Improved by Application of New Preparation Methods

THE aircraft engine of 1943 weighs only only about half as much per horsepower as did the engine of World War I. This decrease in specific weight per horsepower is due primarily to improvement in fuels, increase in engine speed, and general improvement in engine design, but the basic useful strength of the materials employed has not been greatly altered.

There is, however, a great deal to be done in increasing "fatigue strength" of many machine parts. It is not mere stress that causes breakdown of engine parts but fatigue, since alternating cycles of stress occur hundreds of thousands of times. J. O. Almen, of the Research Laboratories of General Motors, in a paper entitled "Shotblasting to Increase Fatigue Resistance," read before the Society of Automobile Engineers, brings us some entirely new concepts of fatigue resistance, Mr. Almen says that the fatigue strength of the most carefully prepared specimen is increased if a thin layer of the specimen is pre-stressed in compression by being hammered, swaged, or shotblasted, or subjected to pressure by balls or rollers. The new process deserves careful attention by our aircraft engine constructors, and has further implications in many other industries.

ENGINE RUGGEDNESS

Demonstrated by Bullet-Drilled Valve Stem

JAP Zeros may be excellent in maneuvers, remarkably fast on the climb and, on the whole, not bad fighting ships, but they cannot take it; they literally explode when caught in the fire of one of our carrier-based fighters. It is not too much to say, on the other hand, that our aircraft and our aircraft engines lead the world in ruggedness and reliability. The photograph of a Thompson Products valve from a Wright Cyclone engine, with a quarter-inch bullet hole through the valve stem, proves our point. The Wright Cyclone was in use in an American-built Curtiss Mohawk (75-A) fighter in the Far East. When the quarter-inch bullet pierced it, the valve stem should have broken instantly and wrecked both engine and airplane, but, as a mater of fact, the engine functioned perfectly for 110 flight hours and went through a dogfight. Ordinarily a valve of the sodium type, when the sodium is shot out of it, should burn and cause trouble. But even though the cooling sodium had run out through the bullet hole, the stem with its superfine steel structure continued functioning.

Pierced . . . but still functioned

ONE hundred and forty years after the Declaration of Independence of 1776, another declaration of independence was proclaimed to these United States, leading to freedom from reliance on Europe for dyes and other organic chemicals.

By 1916 Germany had been blockaded and shut off from overseas commerce for two years. Up to that time America had been almost wholly dependent upon this foreign source for the dyes and other chemicals essential to the great textile industry of the United States.

In 1916, evidences of our lack of good dyes were numerous. The housewife complained about the difficulty in obtaining the multi-colored fabrics to which she was accustomed. What colored materials she was able to purchase proved to be poorly dyed. Never was fading of fabric colors so pronounced as in the years of the last war. Our entry into the conflict in 1917 accentuated this deficiency in quality dyes. The color of the Yanks' uniforms depended upon how many times they had been washed. Indeed, it was the privilege and habit of the recruit in World War I to give his new uniform a severe scrubbing to remove much of the khaki color and make him appear to be a veteran.

It was during those critical days that America declared its second independence and started to develop its own dyes industry. Certain American chemical manufacturers, encouraged by the textile industry which had been so badly disrupted by the lack of essential materials, decided to enter the field. They learned at once that the establishment of a dyes industry offered little in volume of business. America's total dyestuffs bill at that time amounted only to approximately 25 cents per person per year. Thus a potential thirty million dollar business would necessitate research expenditures running into millions of dollars before any actual production started. The dyes industry, furthermore, was not made up of a mere 10 or 20 products, but of literally thousands. Each color, though sold only in relatively small quantities, had a definite place in leather, paper, or textiles. Mass-production methods were not adaptable to the synthesis of dyes and chemicals in closely related fields.

The few colors and related products—such as medicinals and perfumes—which were made in America before 1916 were largely derived or manufactured from chemicals imported from Europe. It was necessary, therefore, to build an American dyes industry from the ground up. The foundations lay deep within the iron and steel industry, for in the coal tar derived from the by-product coke ovens of this industry are found the five essential materials from which all synthetic dyestuffs are made—benzene, toluene, xylene, naphthalene, and anthracene.

Dyes Will Be Even Better

Freed by Intensive Research from Dependency on Foreign Sources, the American Dyes Industry is Now Contributing Largely to the Development of All Branches of the Chemical Industry. After the War it Will Be Producing New and Improved Products for Peacetime Consumption

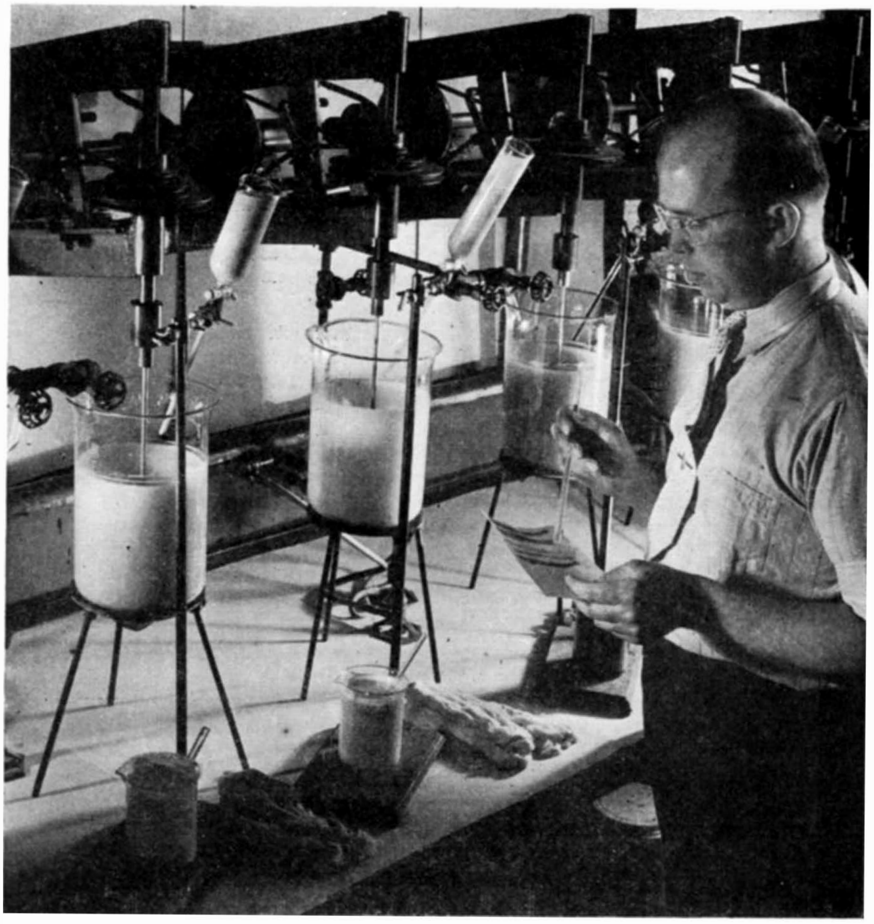
DR. J. H. SACHS

E. I. du Pont de Nemours and Company

Coloring matters as such do not exist in coal tar, but from these five materials, derived from coal tar, dyes are made by various combinations of the essentials. For example, aniline is made from benzene, while beta-naphthol is derived from naphthalene. A combination of aniline and beta-naphthol gives a dye. These five materials can best be likened to five different kinds of clay, from each of which can be made a great variety of bricks. "Bricks" made from benzene, toluene, and the others are arranged pattern-wise into thousands of possible combinations, each combination representing an individual so-called coal-tar dyestuff.

The years 1916-1920 witnessed the first real production of American colors. These initial colors were the simplest and, generally, the least fast. Better and more complicated dyes came later. Progress was gradual. More complicated colors were first studied in the research laboratory, subsequently made in semi-scale plant equipment to prove the laboratory process, and finally produced in full-scale plant equipment. By 1919-20 the first of the anthraquinone vat dyestuffs, the fastest known colors, were produced on a limited scale.

The financial depression of 1921 ruined some firms, but did not halt research and development of dyes and related chemicals. By 1925 it could be said that America possessed an organic chemical industry. Compounds used in the petroleum, rubber, and numerous other indutries were developed as the result of dyes research. Taking synthetic indigo as a measuring stick, Table 1 clearly shows how this



Laboratory equipment for converting water-soluble dyes into insoluble pigments. Dyes are employed to a large extent in printing inks, paints, varnishes, and so on

Much yarn is dyed in what are known as "packages." These are steel bobbins wound with yarn which are placed over circular tubes in a cylindrical machine and the cover bolted in place. The dye liquor is pumped through the tubes and forced out through the yarn. Shown is a laboratory package dyeing machine which is, in every respect, a small-scale duplicate of its counterpart used in commercial production

country achieved chemical independence.

The selling prices of dyetuffs declined as production increased. In 1918 indigo sold for 88 cents a pound, in 1920 for 74 cents a pound, in 1922 for 24 cents a pound, and in 1925 for 16 cents a pound. The year 1920 was the last in which the sales value per pound of domestic dyes averaged in excess of $1.00 per pound. The average value

Table No. 1

Year	Pounds of synthetic indigo domestically produced
1914	None
1918	3,083,888
1920	18,178,231
1922	16,106,020
1925	24,449,938
1930	24,326,403
1940	11,009,307

in 1920 was $1.07 per pound, while by 1930 it had dropped to approximately 43 cents. This reduction was achieved despite the fact that from 1920 to 1930 the production of the more expensive anthraquinone and thioindigo vat colors increased tremendously. Comparative data on total production of these fast vat colors, costs, and sales values are available from 1925, as is indicated in Table 2.

Actually, the weighted average price per pound of domestic dyes increased between 1930 and 1940. Selling prices of individual colors did not advance, but there was a greatly increased use of the better and more expensive dyes—anthraquinone vat colors. These were the dyes which the Germans believed to be their very own in 1916. They boasted that no other country possessed the chemical skill to produce them, that they had no fear of American encroachment. Today we manufacture over two million pounds per month of anthraquinone vat dyestuffs, these vat colors now being used almost exclusively in the dyeing of cotton uniform cloth.

Gradually over the years United States imports of foreign dyestuffs have decreased so much that in 1938, the last full year prior to the outbreak of war, they amounted to less than 20 percent of the value of all dyes sold in this country. During these same years our dyes were being used all over the world in constantly increasing quantities.

American dyes today are the equal of or superior to any in the world. This quality is ever being improved. What was considered the fastest color in 1920 has since been immensely improved upon. Colors of unprecedented fastness have been developed and manufactured. New colors often are more expensive, but consumers long ago learned that the purchase of a poorly dyed fabric constitutes an economic waste. The few cents additional cost of a fast-dyed fabric is worth many times the small difference.

One color in particular is outstanding among all others—Anthraquinone Vat Khaki 2G. It is so important to the military that the production of this color alone is more than 30 times greater than before the war, and manufacturing capacity is being further increased.

Table 3 illustrates the complexity of this particular color. In this table are given the chemical formulas, as the dye chemist writes them, of benzene, naphthalene, and anthracene. Also given are the formulas of indigo which, with aniline as the intermediate product, is derived from benzene; of Thio Indigo Brown G which, with thio-beta-naphthol as the intermediate product, is derived from naphthalene; and of Anthraquinone Vat Khaki 2G which, with anthraquinone as the intermediate product, is derived from anthracene.

Of course, the layman will be unable to carry such formulas in mind, but a survey of them will give him an idea of what it takes to produce the basic color used to dye the cotton cloth for soldiers' uniforms.

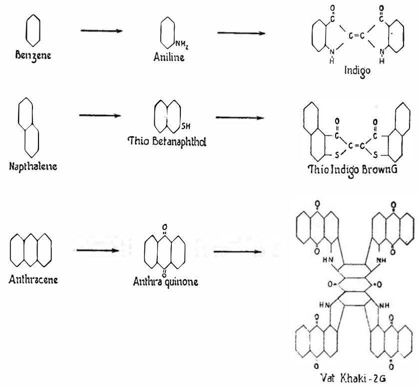


Table 3

Another one of the anthraquinone vat colors used in increasingly large amounts for the dyeing of OD shades on uniform cloth is a product of the inventiveness and ingenuity of the American dyestuff chemist. In fact, there are at least a dozen anthraquinone colors which have been discovered by our chemists as new chemical identities. Some are used in relatively small quantities for special purposes; others in quantities running into the thousands of pounds per month.

The quantity of fast colors available to civilians now and for the duration is governed completely by the military. Like many other commodities—steel, gasoline, coal, for example—dyes are needed in record quantities for essential purposes. What colors are portioned for civilian fabrics changes almost from day to day. So far there have been substantial quantities of fast dyes for civilian textiles, but the requirements and supplies for the months ahead are not easily predicted.

Table No. 2

Year	Domestic Production	Sales of Domestic Production	Total Value of Domestic Sales	Value per Pound of Domestic Sales
1925	86,345,438 lbs.	79,303,451 lbs.	$37,468,332	$ .47
1930	86,480,000 lbs.	89,971,599 lbs.	38,621,610	.43
1935	101,933,000 lbs.	97,954,000 lbs.	51,488,000	.52
1940	127,834,000 lbs.	122,677,000 lbs.	76,432,000	.62

Do you know the two big differences between the JAPS and the CHINESE?

Anthropologists who have carefully studied the *physical* characteristics of the Japs and the Chinese say they have been unable to produce a sure guide for distinguishing between the two. They say some Japanese look like some Chinese and vice versa.

But there are two big differences between them that are of far greater importance to Americans than skin color, set of the eyes or facial shape:

Difference No. 1. The Japs are our enemies; the Chinese are our friends.

Difference No. 2. The Japs have a modern industrial organization for turning out the weapons of war. By comparison, the Chinese have little in the line of industrial equipment.

Thus we find the Japanese soldier attacking China well supplied with planes, artillery, tanks and other modern equipment. His opponent, the Chinese soldier, is armed with magnificent courage, determination and belief in democracy—but is short of arms and ammunition.

Today it is up to the industries of America to help remove this great handicap. Americans must supply the guns and planes and bombs and gasoline the Chinese cannot make for themselves . . . materials they will gladly use to kill Japanese.

Remember: a Jap killed by the Chinese is one less Jap for Americans to take care of.

Among the many materials needed in today's mechanized warfare is Ethyl antiknock fluid, which is used in high-octane military gasolines. The 4000 people engaged in manufacturing Ethyl fluid are making enough to supply not only our own armed forces, but those of our Allies as well. They know that today "Every drop of Ethyl counts."

ETHYL CORPORATION

Chrysler Building, New York City

Manufacturer of Ethyl fluid, used by oil refiners to improve the antiknock quality of aviation and motor gasoline

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

The establishment of an American dyestuff industry has had numerous repercussions in other lines. Naturally, such an industry requires a nucleus of highly trained personnel, a personnel schooled in both research, production, and engineering. Chemists and engineers trained in dyes have expanded their research activities to discover and develop related products, and others have contributed to all branches of the diversified chemical industry.

Synthetic camphor is an example of a product developed by these men. For many years the world depended entirely upon Japan for its camphor supply. Today the United States is manufacturing its own camphor requirements with a process developed by men who were primarily dyes chemists. Neoprene, the first synthetic rubber to be produced in America, and a product which has assumed tremendous importance in our war economy, was likewise developed and manufactured by men whose primary business was the manufacture of dyes. The first pound of sulfanilamide produced in America was made in the research laboratory of one of our largest dyes manufacturers, and production of sulfa drugs today is being carried out largely by a leading dyes manufacturer.

Every dyes chemist and engineer, whatever branch of the industry he serves, is busy today. Some are helping make record quantities of synthetic rubber, high-octane gasoline, and other war necessities. Others are doing confidential research for the government. And still others are manning the great new military explosives plants. Had not a dyes industry been founded here in 1916, we would not have had the synthetics so vital to our war effort, nor the personnel to make them.

After the war, all these chemists and engineers will be available for peacetime research and development. They will then produce new and even better dyes and new and better synthetics to enhance our standard of living.

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FAST PHOTOS

Enable Research Scientists to Study Explosives

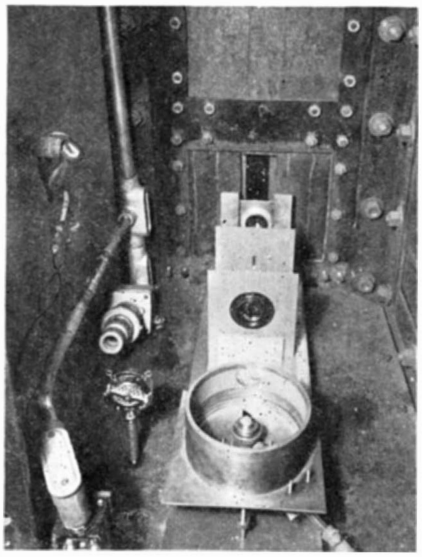
Two of the world's fastest high-speed cameras are being used to photograph the detonation waves of explosions, which travel 5 to 25 times as fast as sound. These cameras record explosions of one-kilogram charges that are about six inches long, and a "slow" explosion is one that lasts about one hundred millionths of a second.

Perfected by Dr. Robert W. Cairns, a physical chemist who is now director of the Hercules Experiment Station, one of these units, called the rotating drum camera, has been in use more than five years. It is fast-moving enough to record all details of the lightning-quick activity when an explosion detonates.

Although the rotating drum camera is sufficiently fast to photograph the detonation wave of any explosive, a second camera, ten times as fast—called the rotating mirror camera—has recently been perfected to photograph highly-refined measurements.

With these cameras, explosives experts can see exactly what happens during detonation, and also what took place at every instant during the explosion, even down to "instants" as short as one ten millionth of a second. Findings based on this research photography are invaluable in the study of the behavior of various types of explosives.

A comparatively "slow" explosive, for instance, is a grade of dynamite used in coal mining to prevent pulverizing the coal, whereas certain military explosives



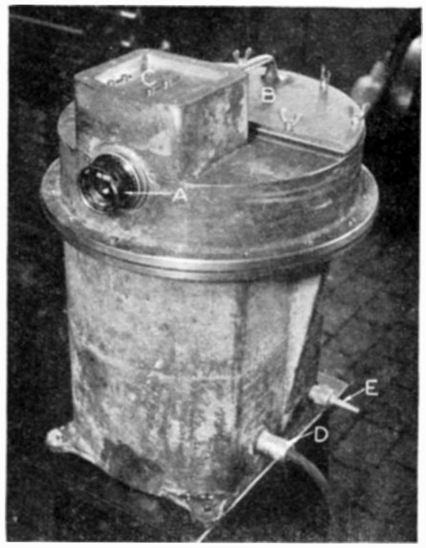
should be rapid-detonating to secure maximum destruction of enemy ships, tanks, and installations.

The Hercules cameras are set in a special explosion-proof shelter on the grounds of the chemical company's main laboratories outside Wilmington. Inside the shelter is the explosion chamber, about the size of a small room. The walls of the shelter are two feet thick and of reinforced concrete. A narrow passageway winds around the interior, with three right-angle turns, to attenuate the noise of the explosion, and also to keep out daylight. The camera itself is mounted inside a steel box made from heavy angle iron and steel plates.

To photograph an explosion, experts suspend the cartridge of dynamite, TNT, nitroglycerin, or other high explosive to be detonated, by wire from the ceiling of the chamber. The cartridge hangs one to two yards from the lens of the camera, which is protected by a standard automobile type safety glass window.

From another building, the cartridge is detonated by means of an electric switch. Elaborate safety devices prevent firing of the charge until everyone is out of the danger zone. The flash of light instantaneously produced by detonation of the explosive is the only light in the sealed chamber. The film recording the progress of the explosion is actually a photograph that shows the details of the light flash, its movement and duration.

The explosive charge is loaded in transparent tubes of glass or of cellulose acetate plastic, to enable the



Left: **Double lens system of new camera for high-speed photography.** ***Above:*** **The assembled camera.** ***A*** **is lens,** ***B*** **the cover,** ***C*** **the adjusting screw,** ***D*** **electric lines to motor,** ***E*** **connection to vacuum pump**

camera to record the action of the explosive grains within the tube.

Although an explosion sounds like a simultaneous blast of the entire charge, the camera shows that the detonation wave actually travels consecutively from grain to grain, up the middle of the cartridge from the end at which it is detonated by a blasting cap.

So swiftly does the detonation wave travel along the cartridge that the detonation is substantially complete before the plastic tube has been shattered by its force.

Films taken of the detonation of various types of explosives show a wide range of detonation velocities. Nitroglycerin detonated in a glass tube has been recorded at a velocity of detonation of 300 miles a minute, or 25,600 feet a second, which is approximately 25 times the speed of a sound wave.

Dynamite for coal mining, on the other hand, often is only a fifth as fast.

But even with a "slow" explosive, the detonation has been completed before the sound of the blast reaches human ears.

Detonations of high explosives that occur within only a few millionths of a second are among the most rapid actions that have been measured. One of the fastest known to the layman is the blinking of an eye, which medical scientists have measured in hundredths of a second. Detonation waves of explosions travel 10,000 times faster.

RHENIUM

Now Available To Researchers From a Domestic Source

For the first time since its discovery in 1925 by Ida Eva Noddack and Walter Karl Friedrich Noddack, German chemists, the extremely rare metal rhenium has been extracted from a domestic ore by-product. Discovery of the American source and a satisfactory method for the recovery of the metal therefrom is announced by A. D. Melaven and

J. A. Bacon of the Department of Chemistry, of the University of Tennessee, at Knoxville.

The source material from which the rhenium has been extracted is a flue dust obtained from the roasting of a molybdenum ore mined in the western United States. The rhenium, occurring to the extent of a few parts per million in the original ore, is concentrated to the extent that the flue dust by-product from the roasting operation contains from 10,000 to 15,000 parts per million of the metal, the roasting operation at the same time converting the metal to a soluble compound form.

The recovery of rhenium in the form of one of its pure compounds is accomplished in three relatively simple steps. The flue dust is first treated with water to remove the soluble compound of rhenium from the insoluble materials. The water extract is then treated chemically to effect precipitation of the metal in the form of potassium perrhenate.

The product of this precipitation contains approximately 30 percent of the metal by weight. Final purification of the potassium perrhenate is accomplished by subjecting the crude material to a series of washings and reprecipitations. The free metal may be obtained from this pure compound by one of several available methods.

Prior to the work by the University of Tennessee chemists, all of the rhenium sold in the United States was imported from Germany. Since the outbreak of present hostilities, available supplies of rhenium for research and other purposes in this country dwindled to the point of virtual non-existence.

The metal rhenium, while having unique properties of its own, bears some resemblance in physical properties and chemical behavior to the more familiar molybdenum, tungsten, and manganese. Its high melting point among metals is exceeded only by that of tungsten, and its density, greater than that of gold, is exceeded only by platinum, iridium, and osmium.

Being a relatively recent addition to the list of chemical elements, its potentialities as a material of future industrial and economic importance have not been fully exploited. However, research on the element with the view of finding important uses for its unique properties is underway in several laboratories.

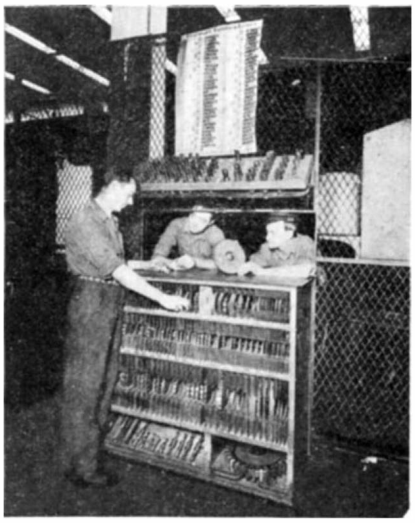
TOOL CARE

Speeds Industrial Production, Places Responsibility

Good housekeeping as far as the care of tools is concerned, as shown by the accompanying photograph of a cutter cabinet inside a tool crib at the General Electric plant in Philadelphia, is helping speed war production in many American war plants.

One of the most successful tool practices is the crib system which classifies tools and equipment used in the shops. Under this system, employees are responsible for the tools that they use.

Some tools may be kept for an indefinite period, while others must be turned in at the end of the shift so that workers on the following shifts may



Good housekeeping speeds production

have the use of them. Many of the tool cribs are equipped to repair worn or damaged tools. Tool crib stocks are replenished from central tool crib stock rooms. Special metal boxes, each marked with the number of the tool crib from which it came, are provided for delivery of tools and equipment from the central stock to the individual tool cribs.

BOMBER CEILING

Boosted by New Generator Brushes

A new chemical development that enables American bombers to fly higher into the sub-stratosphere and stay there longer increases by 50 times the high-altitude life of carbon brushes for airplane generators. The brushes were developed by Dr. Howard M. Elsey, research chemist at Westinghouse, and have been made available to all companies producing air force generators.

Brushes are the bars of carbon which pick up power from the generators and relay it to the plane's electrical system. If they fail, and the batteries are drained, a bombing plane's radio, radio compass, landing gear, lights, and other vital auxiliaries cannot operate.

Research Chemist Elsey, who developed new 'plane generator brushes

"Generators equipped with treated brushes," Dr. Elsey says "are now able to deliver electric power at normal capacity for 100 hours or more above 30,000 feet. Untreated brushes wear out in an average of two hours and they may fail in a few minutes if the generator is called upon to deliver large amounts of power."

The new brush development simplified the problem of providing electric power to pump air into a sealed bomber cabin, keeping the crew alive at altitudes around 40,000 feet. Without the new high-altitude brushes, pressurized cabin planes would have to carry more or larger generators to insure enough power for the pressurizing pumps. This added load would hold down their ceiling.

Dr. Elsey's process involves impregnating the porous carbon with a chemical ingredient that becomes a lubricant when the brushes are pressed against the revolving copper commutator by strong springs. This ingredient puts a film on the copper to lessen friction that rasps ordinary brushes into powder at altitudes above 25,000 feet. The chemical itself is being held a close military secret.

"Untreated brushes," he explained, "were satisfactory for low-altitude flying but beyond 25,000 feet under 'fighting' electrical loads they disintegrated into dust in a few hours. This limited high-altitude flights, endangered trained crews and valuable ships, and necessitated frequent 'time out' from flying for brush replacement."

SPONGE RUBBER

Substitute Derived from Linoleic Acid

A major research contribution to the war effort is in the form of an urgently needed substitute for sponge rubber made of linoleic acid, a derivative of vegetable oils, developed in the Research Laboratories of Bauer and Black.

The sponge product can be made in any thickness and in varying densities. It has a useful property of vulcanizing directly to many surfaces such as metals and plastics and it has flex-cracking resistance which improves at lower temperatures—the direct opposite of sponge rubber made from natural rubber. In many other respects the properties of the new substitute are so close to those of rubber that they appear identical.

PATTERNED GLASS

Diffuses Light, is Decorative, Has Many Uses

Flat glass sheets that are now being made in 12 distinctive patterns have a wide potential use in many places where plain glass is now used and in places where it will replace other materials with greater satisfaction or utility.

These glass sheets, available in tempered form, are so patterned as to diffuse light and to give a variety of appearance. They are being used in partition doors and sections, **for shelving** and shower stalls, for windows and change plates in cashier's booths, for oven lining and shelving, as sludge plates in sewage disposal plants, in connection with built-in lighting fixtures, and so on.

"DISTILLED" WATER

Produced Chemically for Industrial Applications

PRODUCING mineral-free water by an entirely chemical treatment is one of the recent developments in the science of water conditioning. The age-old method of producing distilled water was to boil off the water, leaving the minerals. This method required huge stills and tremendous quantities of heat. The new Permutit "demineralizing" process requires merely passing water through beds of chemicals to remove the harmful minerals, producing "distilled" water at a cost often as low as 5 percent of the cost of distillation. The importance of this process is indicated by the fact that today's war industries require tons of such purified water.

In the "demineralizing" process two steps are required to produce synthetic distilled water. In the first step, calcium, magnesium, and sodium ions in tap water are removed by "ion-exchange" zeolites. The second step involves absorption of the resulting acids formed in the first step. The final water is suited for industrial processes, boiler feed water, manufacturing, and so on.

"Demineralizing" has proved applicable to storage batteries, alcohol deproofing, brewing, preparation of photographic film, soda water, and other consumer products. Adaptations of the process have also found special applications, such as purifying sugar and increasing yields from sugar cane, purifying gelatin, recovering metals from industrial wastes, and so on.

POST-WAR HOMES

Will be Cheaper, Better, Because of Science

THE American who plans a post-war home, the architect who designs, and the builder who constructs it, stand on the threshold of an exciting adventure, in the opinion of E. B. Alvord, head of the Specialty Chemical Section of the Du Pont Company's Grasselli Chemicals Department.

His vision of tomorrow's home, shaped out of newly-developed materials which have been severely tested in the crucible of war, is a challenging picture.

The house of the future will almost certainly be made of standardized, mass-produced parts. Owner and architect will assemble the parts in any shape and form desired. Such a home will be enormously cheaper than those of today —estimated by some authorities at $500 to $800 per room.

It was reported that plywood adhesives recently perfected for the aviation industry will be available after the war in great quantities. Thin sheets of "veneer," or ply, bonded with these new glues, can be bent or molded into practically any shape desired. Plywood furniture, bathtubs, light walls, and movable partitions as strong per unit of weight as steel will go far toward making possible the inexpensive and durable house of tomorrow.

"Take wood, for example," says Mr. Alvord. "Chemical science is capable of endowing wood with qualities that vastly improve upon Nature. Retaining all its inherent advantages for construction—workability, economy, low heat conductivity, and ease of replacement—the chemist can supply the post-war building industry with lumber treated so as to be a distinctive structural material in its own right.

"In the chemical transformation of wood," says Mr. Alvord, "another substance known as crystal urea shows great promise. Green woods, impregnated with urea and dried, become relatively plastic when heated. They may be bent, twisted, and compressed. They retain their new shapes, resuming their normal rigidity and hardness, when cool.

"Plastics formulated from cellulose, the skeleton, so to speak, of trees, and from other sources, will be used widely by the building and furnishing industries. Everything from luminous light switches to decorative pieces are predictable.

"There have been significant wartime advances in finishes technology that will be adaptable to the beautification and protection of peacetime dwellings. Finishes research lately has been producing 'tailor-made' particles to give paints special characteristics for special uses.

"Air-conditioning will eventually become as standard a part of the American home as the cook stove," Mr. Alvord points out. "The very same safe refrigerant that you may have today in your present refrigerator is being manufactured in quantities far exceeding pre-war needs."

CONVEYOR BELTS

Being Used at Highest Earthen Dam

With resumption of work on giant Anderson Ranch Dam in the south fork of the Boise River, Idaho, conveyor belts will become the main haulage system for the first time in construction of an earthen barrier. Nearly 30,000 feet of belts supplied by the Goodyear Tire and Rubber Company will be used to handle most of the 12 million cubic yards of clay and other types of soil needed for this, the highest earthen dam in the world.

Supplementing another flood control and irrigation dam further down the river, the Anderson Ranch Dam will be 444 feet high above its foundations and 350 feet above the stream bed. Its construction is expected to require several

One of the nine long conveyor belts in use at a western dam

years. The river's flow is being diverted through a 1600-foot tunnel, 20 feet in diameter, until the dam is completed.

Nine flights of belts in 36-inch widths will carry impervious clay for the core of the dam from a borrow pit a mile and a half away. Several 60-inch belts will help provide the pervious material for the exterior from another borrow pit.

In this belt-conveyor project are included all the Goodyear developments worked out for other projects such as the 10-mile conveyor system at Shasta Dam; pneumatic tires beneath the belts as at Grand Coulee Dam; and double counterweighted "dipsy-doodles" as at the Permanente cement mill in California.

Another feature of the Anderson Ranch Dam belt-conveyor installation is the fact that the belts will generate some of the electricity needed for the dam's construction. In addition to providing electricity, generators on the belts also act as brakes to prevent too rapid speeds.

CONDUCTIVE HEELS

Remove Danger from Static Sparks

ALMOST perfect protection for such diversified workers as munitions makers and hospital attaches, a rubber heel which conducts electricity instead of insulating against it has been announced by The Goodyear Tire & Rubber Company. By means of a special rubber compound of which the heels are made, static electricity within a worker's body is carried off almost at the time of inception. Thus a sufficiently large accumulation of electricity to cause a dangerous spark is averted.

With normal rubber heels, the static electricity accumulates within a worker's body until it generates a spark strong enough to go through the heel and, at the same time, strong enough to be dangerous.

On hospital shoes, according to Goodyear, the conductive rubber heels perform an important function by protecting patients from dangerous sparks while undergoing operations in which electricity is involved. They also guard patients against other vagrant sparks of static electricity from doctors and nurses.

Now being produced in large quantities, mainly for munitions makers, the conductive rubber heels are built with brass washers instead of conventional steel in order to provide better adhesion with the rubber. Each heel, before leaving the factory, is carefully tested with a low-voltage electric current passing between an electrode and a steel table on which the inspections are conducted.

CHEAPER ALCOHOL

Process Also Yields Inexpensive Protein

CONCENTRATED protein that can be sold for a little as five cents a pound will soon be available in large quantities as a by-product of alcohol distillation, according to present indications.

The protein—which is almost identical in appearance, consistency, and food value to dehydrated egg white—results from a new process for distilling alcohol discovered recently by government scientists after months of research at the Park and Tilford Distillery.

The discovery, which will have the immediate effect of considerable saving to the government in war-alcohol costs, was made by Irvin W. Tucker, a young chemist in the United States Department of Agriculture working under the direction of Dr. A. K. Balls, chief of the department's enzyme research laboratory. The new alcohol process is unusually rich in both wartime and post-war possibilities, according to Frank G. Handren, president of Park and Tilford Distillers, Inc.

Here are a few of the developments envisaged:

1. Recovery of one billion pounds annually of protein in a practically pure form, which can be used as a supplement to livestock feed, for protein enrichment of white flour for bread and cereals, and for processing into a number of essential chemical products, including casein—which now costs about 20 cents a pound.

2. Complete elimination of barley malt, now the most expensive single ingredient, from the alcohol distillation process.

3. Revolutionizing of the alcohol industry by making alcohol, now the principal product, assume the role of a by-product in the industry.

4. Large-scale production of grain alcohol after the war for synthetic rubber and other industrial products. Hitherto grain alcohol production costs have precluded such a development. The new process, when fully developed commercially, will cut grain alcohol producing costs in half.

At present, malted barley is employed in grain alcohol production because of its high concentration of diastase, an enzyme whose function is to convert the starch of cereal grains into sugar to serve as a digestible nutrient for the growing plant. In the distillation process, the barley malt converts the starch content to sugar, feeding distillers' yeast and giving off carbon dioxide and alcohol as by-products. Natural diastase is present in wheat and other grains, of course, but it is usually destroyed in the cooking process preceding the conversion step in distillation.

Under the Balls-Tucker process, a solution of sodium sulfite—a plentiful waste product of several industries, including pulp and paper, ore roasting and coke making—is used to extract the diastase from wheat before it is cooked. The resulting solution supplants the barley malt hitherto used to convert the starch to sugar after cooking. Simultaneously, the sodium sulphite extracts the protein content of the wheat, which rises to the surface as a thick, yellow froth.

Little, if any, additional equipment at distilleries is needed to separate the diastase-containing froth from the virtually pure residue of starch. Drying out the froth is a simpler task than the ordinary distillery recovery process or than the more elaborate methods required to recover the spent residue of wheat. It is wheat, instead of the customary corn, that distillers are now using for war-alcohol production.

After distilling the alcohol, distillers ordinarily have the residual slop evaporated and dried. The resulting solids are sold to livestock feeders as "distillers' dried grains" for about two cents a pound. The Balls-Tucker process not only extracts the protein—the important constituent of dried grains—but it does so at the beginning rather than at the end of the alcohol production line. This reduces the bulk to be handled in the various stages of production and cuts down the residue to a thin slop which can be disposed of with relative ease.

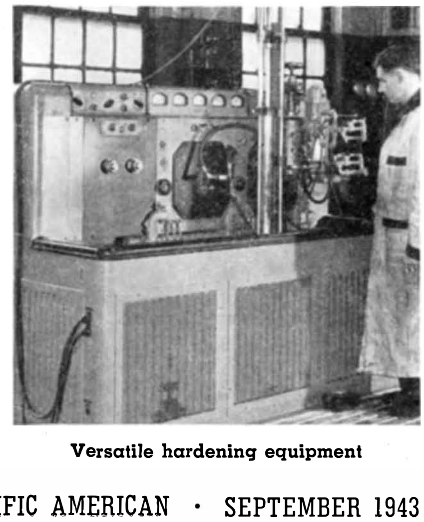
PARTS HARDENING

Speeded, Made Versatile, by New Electrical Equipment

At least 50 percent of the time formerly required to harden a wide variety of Diesel engine parts is now being saved by one company with recently installed equipment for heating and hardening by electrical induction.

Some 35 separate parts, ranging from 7/16-inch bolts to large Diesel wrist pins, over six inches in diameter and up to 18¼ inches in length, are now being accurately hardened to the desired degree and depth, in less than half the time formerly required when the entire parts were carburized.

The simplicity of the process was demonstrated recently by T. E. Egan of the Cooper-Bessemer Corporation, who placed a crankshaft for a Diesel fuel pump into place on the machine. By pressing a button, the selected bearing surfaces of the crankshaft became red-



Versatile hardening equipment

hot within a few seconds, and jets of water automatically sprayed the heated areas, thus quenching and completing the hardening operation.

By merely changing the fixtures and induction coils, many of which are designed and built in the Cooper-Bessemer plant, the machine is prepared to accommodate any one of the 35 items that are hardened in this way, and which include such parts as gears, cams, wrist pins, and ball races.

In hardening wrist pins, for example, an automatic, hydraulically operated fixture is installed which feeds the pin through the induction coils at a controlled speed so that the entire length of the wrist pin is heated to the desired temperature and quenched in one continuous operation.

"Hardening time for a wrist pin," said Egan, "is now reduced to 38 seconds. This process not only completes the work in seconds instead of hours, but also reduces distortion to a minimum and saves critical material by permitting us to use a carbon steel in place of high alloy steel formerly used."

ACOUSTIC STETHOSCOPE

Detects Sounds Within the Body Heretofore Unheard

A NEW acoustic stethoscope, so sensitive in its range of hearing that it introduces many sounds doctors have never heard, promises to widen the study of sound within the human body. The beat of the heart, normal or abnormal, respiratory rattles, peristaltic squeaks, murmurs, and groans, all are amplified to facilitate diagnosis, based upon the structure of sound.

Sounds never heard before

It has been found the sounds of the body range from 40 to 4000 cycles, the full range of which is covered for the first time by the new stethoscope. Above 4000 cycles most of the sounds in the body are so weak that they are masked by the ambient random noises generated within the body. It is explained that respiratory sounds such as wheezes and the rushing of air are of a complex nature. Therefore, in designing the new stethoscope to gain maximum intelligence, the instrument transmits all frequencies over the range from 40 to 4000 cycles without attenuation or discrimination. The ordinary stethoscope has an effective range between 200 and 1500 cycles.

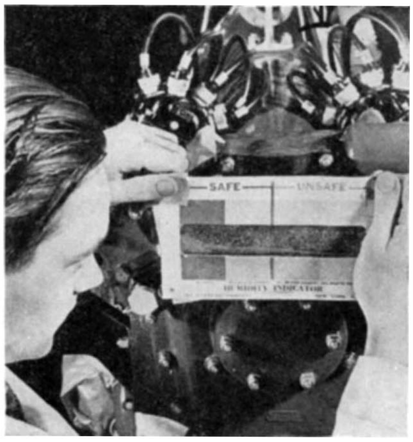
The advantages of the new stethoscope, according to Dr. Harry F. Olson, come from the fact that it couples the ears of the diagnostician much more closely to the human body through the employment of a reversed taper tube which results in greatly improved matching of the acoustic elements. Thus, sounds produced by the organs of the body are heard more clearly and their range is greatly widened.

In fact, so many new sounds are heard with the instrument, developed by RCA Laboratories, that a filter is built into it to enable the user, by simply turning a knob, to limit the range at will. This was done at the suggestion of one of the testing physicians in order to prevent confusion until the meaning of the new sounds can be determined through further study.

HUMIDITY INDICATOR

Supplements Work of Silica Gel

An "automatic weatherman" that signals shippers and stevedores when the humidity inside munition crates rises to the rusting point is the packaging expert's newest means of protecting guns and engines from corroding during the weeks and months they lie in freighter holds and humid dockyards.



Color tells the story

Enclosed with a silica gel rust protectant developed by The Permutit Company is a weatherman of cobalt-impregnated gel functioning like the old-fashioned Dutch-boy-and-girl weather indicators which warned of rain by turning pink. When the humidity in a package rises above the critical point, the weatherman—visible to inspectors from the outside—turns pink, indicating leakage of the moisture-proof bag in which the metal part is packed.

GLASS RECTIFIERS

Now Being Used for Industrial Alcohol Production

A marked speed-up in the rate of distillation of the rectifying columns used by the beverage distilling industry to produce 190-proof ethyl alcohol required for explosives, synthetic rubber, and other war and essential civilian uses, has been made possible by the development by Owens-Corning Fiberglass Corporation of a new glass fiber packing material for the columns.

The glass fibers can replace both the tinned-copper bubble plates with which the industry equipped its columns before Pearl Harbor, and the burned-clay Raschig rings which the industry resorted to as a substitute when tinned copper became unavailable. It is believed that the material will also prove practical for use in distillation applications in the chemical, petroleum, and other industries.

A principal factor in determining the rate of distillation of an alcohol rectifying column is the amount of exposed surface area which is presented for the condensation of water and other liquids. The ability of the glass fibers to increase the rate of distillation is due to the great increase in exposed surface area presented by the fibers, as compared to the exposed surface area presented by either the bubble plates or the Raschig rings.

One method employed in packing the columns with glass fibers consists of placing them in large, expanded-metal baskets which fit, one over the other, into the inside of the column. When used at their normal density of 3.5 pounds to the cubic foot, the fibers present 135 square feet of exposed surface area per cubic foot. This compares with an exposed surface area of 56 square feet per cubic foot when the Raschig rings are used.

The operation of columns packed with glass fibers is identical with that of columns packed with Raschig rings, or fitted with bubble plates. Heated vapors from stills producing the normal run of 120-140 proof alcohol pass up through the column. Water and other liquids with a boiling point higher than the 170 degrees, Fahrenheit, boiling point of ethyl alcohol condense on the bubble plates, Raschig rings, or glass fibers, and flow back to be re-heated and revaporized by the rising vapors from the still, until the last vestige of alcohol is extracted from them.

The vapors which finally pass out through the top of the column into a condenser become 190-proof alcohol with only 5 percent of water content.

GLASS KITE STRING

Used to Carry Radio Antenna Aloft

A kite string of glass yarn is used with the box kite that carries aloft the antenna of the portable, hand-generator radio transmitter developed by the Army Air Forces to summon help for fliers forced to make crash landings at sea.

The complete transmitter kit for use on aircraft life rafts includes the sending set, an ordinary cloth and wood-frame box kite, an antenna consisting of very fine copper wire wound around the glass kite string, two balloons, and capsules of compressed hydrogen. The ballons, inflated with the hydrogen, can be used to carry the antenna aloft in the event of a calm.

Glass yarn is used as the kite string because of its great strength in proportion to its weight, and because it will not rot or otherwise deteriorate from the effects of salt water, tropic sunlight, rain or dampness. The yarn is twisted and plied from continuous filament glass fibers which can be drawn to indefinite lengths, measurable in miles.

The transmitter is so constructed that the operator needs no knowledge of radio or code. When the hand crank is used to generate power the transmitter automatically grinds out the SOS signal on 500 kilocycles, the international distress frequency.

"FOOTPRINTS" IN LACQUER

Reveal Secrets of Strains in Metal

THE lacquer-held "footprints" of a bullet crashing into steel plate are giving experimental scientists new information which may aid in the development of tougher armor plate and better armor-piercing shells for the nation's fighting men. The "footprints" are thin, closely spaced cracks which appear on a lacquer-coated steel target under the impact of a bullet. Dr. Miklos Hetenyi is conducting the experiments in the Westinghouse Research Laboratories.

"Some shots fired in the laboratory," says Dr. Hetenyi, "create a heart-shaped pattern extending six or eight inches from the spot where the bullet hit or penetrated. In other tests the cracks form a series of circles around the bullet hole. Each tiny crack denotes stretching of the metal underneath the lacquer and gives us a permanent picture of the strains that occurred at the instant of impact."

By spraying this smooth lacquer coating, known as Stresscoat, on metal parts and then contorting them until the brittle skin cracks, research engineers can also detect vulnerable spots in

A bullet's "footprint"

gears, shafts, valves, and other parts of vital wartime equipment.

"This lacquer coating test," Dr. Hetenyi says, "is accelerating improvements in motors, gears, and various types of electrical machines because it enables us to locate strains quickly. Of course, 'life' tests are still necessary but the cracked coating process tells us when we are on the right track in designing new parts."

Just as yawning crevices opened by an earthquake reveal faults deep un-

Spraying a gear tooth for test

derground, tiny fissures in the lacquer tell a story of the strains that machine parts experience. Cracks in the glossy finish pick out the "Achilles heel" of an eight-foot-high two-ton gearwheel or bare the weak points of a flapper valve, a tenth-of-an-ounce slice of steel that vibrates back and forth in air cooling machinery.

In one test the lacquer coating was put on a 1600-pound "model" of a gear tooth; the tooth was then squeezed in a large hydraulic press to locate the stresses accurately. Results of this work were turned over to the Nuttall Gearing Works of Westinghouse which is manufacturing gears for submarines, subchasers, and other war equipment.

Lacquer sprayed on the gear tooth dries in 15 hours to form a tightly clinging skin about as thick as the diameter of a human hair. To determine the slightest strain that will crack this coating, a foot-long steel bar is sprayed at the same time as the gear tooth and under the same atmospheric conditions.

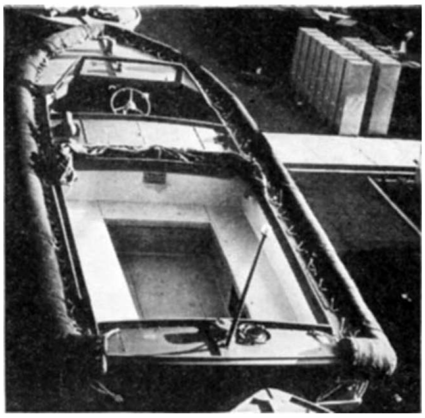
The steel bar is bent in a machine that holds it rigid at one end and depresses it at the other. Most of the cracks in the coating appear at the rigidly-held end and become less frequent until there are none at the end which was pushed down. Then the bar is placed beside a strain scale which is read opposite the point where the last crack occurred.

BOAT BUMPERS

Being Made From Rubber Cushions

PEACETIME'S bus, railroad, and automobile cushions and similar products made of foamed rubber are going to war in a new guise: They're helping to protect seaplanes and flying boats from damage in rough water at bases and harbors all over the world. To this end a supply of Airfoam products no longer useful for their original purposes is being converted into protective paddings for the gunwales of United States Navy personnel boats which service seaplanes.

The production of civilian products with Goodyear Airfoam ended with Pearl Harbor, and the present supply of



Rubber boat bumpers

cushions and similar materials being converted to gunwale pads was accumulated before Pearl Harbor. The cushions are cut apart to fit inside tubes of wear-resisting and weather-proof fabric. The tubes are made in such a manner that each short length contains a "V" which fits over boat gunwales. Then the tubes are lashed together into strips which extend for the entire length of a gunwale and the strips are lashed to the boat. Thus the strips are quickly interchangeable from one boat to another as it is placed into or removed from seaplane servicing.

OIL LINE MIXING

Can be Economically Determined in Advance

MORE fuel oil and gasoline will be available for the furnace and automobile next winter as a result of an investigation recently completed by Prof. Geo. Granger Brown of the University of Michigan and Frank C. Fowler of Phillips Petroleum Company (formerly with the University of Michigan) and announced to the American Institute of Chemical Engineers.

In the "big inch" and "little big inch" pipe lines from the Texas oil fields to the Eastern States, a few thousand barrels of fuel oil may be followed by a quantity of aviation gasoline, and that in turn by some other product of the refinery. Naturally, there will be some contamination where two products meet. In order to avoid the loss of considerable volumes of these materials it is essential that the operators of the pipe lines know how much of the oil and gasoline are mixed. This can now be determined in advance. The first public account of the fundamental factors controlling the intermixing or contamination of the various products transported in a pipe line by successive flow was given by Professor Brown and Mr. Fowler. They reported the relationship of the various factors—viscosity of the fluid, diameter of the pipe, velocity of the flow, and length of the pipe line—and their effect on successive products.

Due to the increased efficiency of transporting refined products rather than the crude oil itself, the petroleum industry had previously adopted a practice of refining the crude oil into finished products on the Gulf Coast of Texas and transporting the products by tankers to the East Coast. This procedure is more efficient not only because of the slightly lower fuel cost in Texas, but also because it is not then necessary to transport the "refining losses" but only the actual products which are desired.

In order to utilize the refinery capacity of the country on the most efficient basis, it is therefore necessary to provide adequate transportation of finished products from Texas to the East Coast. This is to be accomplished by transporting fuel oil in addition to crude oil through "big inch," 24-inch crude-oil pipe line, from Longview, Texas, to Norris City, Illinois, and by providing the "little big inch," 20-inch products pipe line, to transport gasoline from the Gulf Coast to the same eastern area. These product pipe lines are a recent development in the petroleum industry and have been used with considerable economies and great success in transporting finished products from the south to the north and east.

ULTRA-VIOLET "LIGHTHOUSE"

Developed to Irradiate Industrial Workers

A NEW type of low-cost miniature "lighthouse" that broadcasts ultra-violet health rays to keep war workers well has been developed by the Hanovia Chemical and Manufacturing Company, and has been installed in a plant of the RCA Victor Division on recommendation of the plant's War Production Drive Committee, in co-operation with the medical staff.

"Standing in a circle five feet from the lighthouse, 15 men or women can simultaneously receive ultra-violet applications within a few minutes, enabling the handling of hundreds of plant workers daily," Frederic W. Robinson,

A "lighthouse" for irradiating industrial workers with ultra-violet

Hanovia's director of research, explains. "Five-minute daily applications are sufficient.

"A novel feature of the new design is that the use of aluminum reflectors is avoided, thus saving critical materials, and, at the same time, the radiation output of the lamp is more fully realized than ever before. Furthermore, laboratory developments on the high-pressure quartz mercury lamp used have resulted in reduced operation costs, making irradiation of large numbers of war workers practical."

Previews of the Industrial Horizon

(*Continued from page 99*)

sections, light weight, good aging qualities, resistance to chemical attack, and moldability with existing equipment with minor modifications. No nylon plastic may be had for the duration, other than for vital military applications, but here is one more development that will leap forward when the bars are lowered.

HIGH-SPEED PHOTOGRAPHY

DEVELOPED for studying the detonation waves of explosives, the new rotating drum camera, described on page 124, is one of those useful scientific tools that will undoubtedly find many uses in industry other than the one for which it was initially designed. Where action—mechanical or otherwise—takes place at high speeds, much can be learned about stresses and so on if it is possible to photograph the action while it is taking place. This can be done with the camera described, adding new chapters to many research stories.

BETTER DYES

DYES DEVELOPMENT, reported on page 121, is part and parcel of the intriguing saga of the growth of the chemical industry in the United States. From work on dyes has come basic knowledge that has branched out into other fields of chemistry; dyes experts are playing a large part in present war-time research; they will be equally important in the field of consumer and heavy-industry synthetics after the war.

SEWAGE TREATMENT

INDUSTRIAL water supplies and power sources are being found in sewage by engineers concentrating on the important problem of sewage treatment. Here is research closely linked with community development that, while it disposes of wastes in a modern and sanitary manner, also provides dollar value in the form of things that industry needs. The post-war world will benefit in more ways than one. For details see page 106.

WHAT SHALL WE EAT?

HOW FAR the food-dehydration industry will affect the eating habits of the people of the United States after the war will probably be largely determined by those men who are now in the armed forces where they are being fed large quantities of dried foods. If they relish these foods and demand them upon return to civilian life, the industry will flourish and prosper; if not, the industry will fall back to those staple forms of pre-war days and will shrink correspondingly.

While dehydration of food serves a very useful purpose where shipping facilities are limited, it will never be an important factor in the food field when these restrictions are removed unless the food is equal in every respect to that obtainable through other means.

HOW HARD IS HARD?

IT MAY come as somewhat of a surprise to those who have never given the matter much thought to find, in the article starting on page 109, that science really does not know very much about the hardness of materials. Many industrial operations are predicated on this factor yet, in the final analysis, knowledge is applied empirically. When restless research finally finds all the answers to the puzzle of hardness, industrial technology will make a long step forward in its methods of handling many materials.

RADIO STANDS READY

THE LARGE part which radio is playing in the war on all fronts foreshadows many of the applications that will become common-place in days of peace. Practical use of developments directly attributable to military requirements will be made not only in the fields of communication but also in that of transportation, among others. Thus we may someday see airplanes, ships, and all manner of ground vehicles being guided through all weather conditions by radio equipment; radio channels will serve as "tracks" which they will follow with absolute safety.

BETTER AUTOMOBILES

DUST, one of the banes of military operations, is a deadly enemy of automotive vehicles, yet up to the beginning of the war it was considered sufficient to provide a carburetor air cleaner and let the dust problem go at that. Now, however, it is found that combat vehicles need far more protection than ever before thought necessary. As a consequence, dust-proofing is being extended to clutches, transmissions, instruments, brakes, and even to fan belts. Out of this work will come dust-proofing of many parts of the post-war "pleasure" car, with resulting longer life of parts, more efficient operation, and fewer troubles.

WEAR-RESISTANT

A COMPETITOR of other and more conventional materials in luggage and packing case construction is seen in a new material that uses blotting paper—no less!—as a base. This paper, as told on page 138, is saturated with a synthetic rubber and processed to become tough and wear-resistant Thus a new and low-cost product looms on the horizon to give added impetus—and variety—to a number of post-war consumer industries.

New Products

CLASSIFYING DEVICE

RECENTLY developed to classify and sort .30- and .50-caliber armor-piercing bullet cores and 20mm shells automatically, a new Toledo Dynamic Classifying Device has many similar applications in other industries. Pieces to be weighed, or classified, must be of such a character that normal variations in weight do not materially effect the position of their center of gravity. Spheres, cylinders, rectangles, and similar regularly formed parts conform to this requirement. Weights from ¼ ounce up to 6 ounces can be handled.


Sorting by weighing

As the parts are fed into the device, they are automatically deposited on the end of a lever. The loaded end of the lever is released, permitting that end to fall (dynamic weighing principle). Parts are weighed in motion, and the interception of a light ray by the weight beam causes a photo-electric cell to operate the mechanism for automatically discharging the parts into one of three chutes, which classifies them as "Under-Weight," "Within-Tolerance," or "Over-Weight."

RESILIENT FLOORS

RECENTLY improved is an asphalt-asbestos floor tile designed for industrial use. The tile surface is resilient and wear resistant, is claimed to be non-slip when wet. The surface is non-sparking and will melt before it will burn. This tile, made by David E. Kennedy, Inc., is finished in three different sizes and seven colors.

WATERPROOF TAPE

FOR sealing water-resistant cartons carrying vital overseas-bound cargoes of ammunition, medical equipment, food, clothing, instruments, and thousands of other necessities, there has been developed a waterproof tape, known as Solseal, which is applied in the same simple manner as regular sealing tape, using the same type of moistening dispenser. A special Solseal solvent, used as a moistening agent, is a non-inflammable, non-volatile, non-corrosive mixture of chemicals that will, upon wetting Solseal, cause it to become waterproof after a 72-hour period. Bondings effected with Solseal Tape, immersed in water under strain, have withstood that immersion for weeks, in some cases over eight weeks, without any releasing of the tape, it is claimed.

CORROSION PREVENTION

PROTECTION of finished machinery and other materials which might corrode during transportation may be provided by bags of silica gel, which are placed in the containers with the material to be protected. The bag containing the gel, manufactured by Culligan Zeolite Company, is made of cloth with a breathing-type paper lining. The gel absorbs all moisture within sealed containers, thus preventing corrosion.

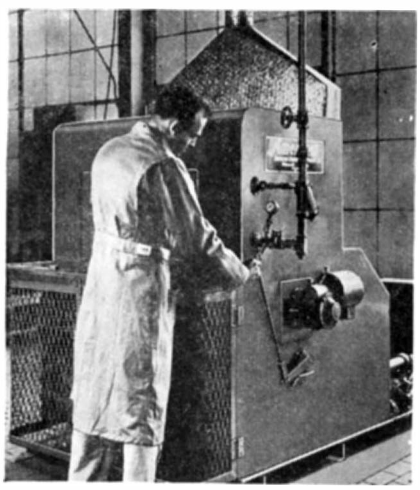
DECALCOMANIA NAMEPLATES

TOUGH and resistant to scratching and wear is a new transfer nameplate made of non-critical materials. It is claimed by the Myercord Company, manufacturers of these nameplates, that they have effectively withstood weathering and salt-spray tests. These included exposure to temperatures of 200 degrees, Fahrenheit, and 98 percent humidity, followed by temperature drop to minus 40 degress, Fahrenheit. The transfers are available for use on polished and wrinkle-finish metal surfaces, designs and colors being to specifications.

METAL WASHING

TO MEET the need for high-speed washing of flat, fragile work or circular parts with intricate pockets and crevices, the Tabl-Spray washing machine has been developed by American Foundry Equipment Company. By complete exposure given the parts in rotating them through the path of well-positioned power sprays, this new unit insures uniform coverage and thorough speed cleaning.

Parts to be cleaned in the Tabl-Spray are placed on the mesh table and


For high-speed parts washing

rotated through the spray solution, discharged from special machined non-clogging nozzles.

After the few minutes required washing time, the solution valve is closed and the parts are left rotating to obtain proper drainage. If rinsing with fresh water is desirable, this operation can be handled without transferring parts to another compartment, by means of a special arrangement of drainplates. A compressed air blowoff can follow the cleaning to remove excess liquid from the parts.

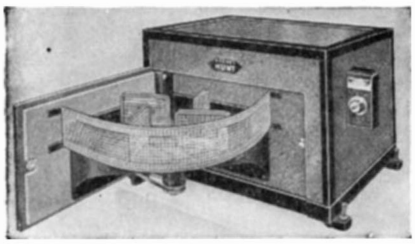
Typical cleaning applications include removing lapping compound, oil, and chips from magnesium and aluminum aircraft parts, cleaning crankcases, supercharger rear housings and adapters, small assemblies, gears, or rocker arms prior to inspection or after magnaflux.

NON-SPARKING CONTAINER

CONDUCTIVE synthetic rubber, made by the United States Rubber Company, is now being fabricated into carrying boxes, buckets, and trays for handling explosive materials. Containers made of this material can not strike sparks; because of the conductive qualities of the rubber, static charges cannot accumulate to a point where disastrous sparks might be discharged.

SAMPLE DRYER

USING a principle different from that usually employed in drying sample swatches of cloth, the Rodney Hunt Machine Company has developed a



Textile dryer and conditioner

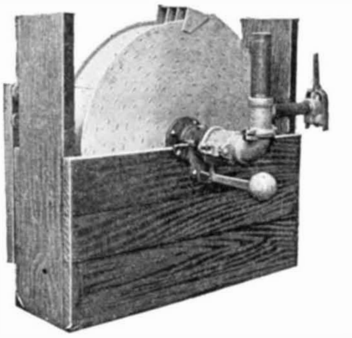
unit to perform this operation at what they state are phenomenally high speeds.

The conventional way to dry samples in a textile mill is over a steam pipe or by a hair dryer. The dyer cuts a sample four-inch square, dries it for 10 or 20 minutes, and then waves it around in the air to condition it to room temperature and humidity before matching. Not only does this take valuable production time but it also gives the cloth in the dye kettle a chance to change shade, lessening the accuracy of the match.

The new unit, known as the "Whirlwind" Sample Dryer, does both the drying and conditioning operations in from one to two minutes, depending upon the material. The process is basically one of rotating the samples at high speeds, first in a dryer cabinet and then in the room at normal temperature and humidity. The samples are placed on wire screens on a disk or rotor which is attached to the inside of the door of an insulated cabinet. The door is closed, the motor turned on, and the samples rotate inside the cabinet at great speed. After the sample is dried, the door of the cabinet is opened and the sample continues to rotate at room temperature and humidity until conditioned properly.

SPIRAL PUMP

WHEN it is necessary to handle liquids containing solids such as sand, abrasives, crushed ore, and so on, a new rotary spiral pump can be pressed into service to handle up to as high as 91.6 gallons per minute. These pumps, in wooden



The spiral does the trick

housings as illustrated, pick up the liquid and solids at the open end of a spiral, setting up a flow through the spiral to an outlet at the center. Rotation speed is 20 revolutions per minute. These pumps, known as the Frenier sand pumps, are available in three diameters with lift capacities from 12 to 22 feet.

THICKNESS GAGE

THE THICKNESS of steel plate can be measured with a new electrical instrument even though access is available to only one side of the plate. This new gage, a product of the Metron Instrument Company, will operate on maximum plate thicknesses up to 5/8 of an inch.

This instrument contains two iron-core magnets connected in a balanced bridge circuit. One of the magnets is designed to be placed against the plate to be measured while the other is mounted on the instrument housing and has an adjustable armature to provide for calibration. Through a balancing of the bridge circuit it is possible to determine the influence of the steel plate to be measured upon a magnetic field. Since this influence is related to the thickness of the sheet, thickness readings can be taken direct from the meter once the instrument has been calibrated.

RIVET BUCKER

AUTOMATIC bucking and riveting by one operator is made possible with the tool shown in these columns. In it a standard rivet set is synchronized with an air

Treadle controlled

cushioned bucker, the two parts always being perfectly aligned to insure accuracy in riveting. The treadle control enables the operator to use both hands for guiding the work. When the rivet set hits the rivet, the bucking bar is always in contact wih the shank.

BRAZING FLUX

WHEN a new granular fluxing material, developed by Chicago Welding Sales Company, is used for brazing of cast iron parts, initial cleaning or grinding of the break to be welded is stated to be completely eliminated.

RUBBER PAPER AND GASKETS

BLOTTING paper may soon go traveling and see the outside of the world's buildings instead of hiding away in desk drawers. The Hycar Chemical Company of Akron has found a spectacular assignment for blotting paper. With this company's butadiene synthetic rubber as a saturator and binder, blotting paper may go into luggage—hand bags, suitcases, fitted cases, even packing cases.

According to tests made in the company's laboratories, highly absorbent blotting paper immersed in the hycar latex, and then dried in an oven, becomes a tough, wear-resistant material that is ideally suited to the manufacturing of luggage items. The treated paper is not affected by oil or other solvents and can be prepared in any of the standard colors.

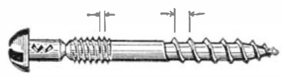
Another use for synthetic rubber, recently announced, is a gasket material consisting of copper mesh coated with synthetic rubber, originated by The Detroit Gasket and Manufacturing Company and produced by The Goodyear Tire and Rubber Company. This rubber-sheathed mesh has survived exhaustive tests and now is standard equipment for many airplane engines produced in this country.

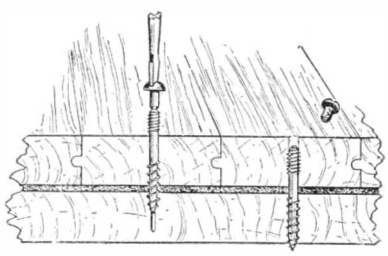
The rubber-sheathed gasket, less than 15 one-thousandths of an inch in thickness, is made of 80-mesh copper screening which has a tensile strength far in excess of any internal pressure which may be encountered. Thus the wire, as a reinforcing medium, provides insurance against leaks due to blowouts, the synthetic rubber coating providing the necessary binding medium for the wire mesh as well as the resiliency required to obtain perfect alignment in the assembly.

LOCKING WOOD SCREW

A WOOD screw that prevents the slipping of any two boards, by locking them permanently, has two threads of different pitches. With each turn of the screw, the boards are pulled together by an amount equal to the difference between the pitches of these threads. This difference in pitch results in obtaining a greater "pulling together" action than can be secured by an ordinary wood screw, plus the equally important feature that, when properly installed, the Wil-Son No-Slip screw leaves only a small hole, in fact not much larger that a nail hole, which can easily be sealed with Plastic Wood or other compound.

When installing the screw, a small hole is drilled to a depth equal to about three-quarters of the length of the screw. The No-Slip screw is then screwed into this hole. The coarse threads first pass through one board and then into the others. The slightly larger fine threads then begin to engage the first board, and, as the screw goes





How the locking wood screw works

down farther, the difference in pitch between the two threads causes the two boards to be pulled together gradually until finally both boards become tightly joined.

The operator then may break off, with a pair of pliers, the top of the screw at the groove which is just above the fine threads. An unusually hard twist on the screw driver will give the same result. When properly installed the breaking off point is always below the surface of the wood.

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.)

CRISIS IN RUBBER is an illustrated pamphlet which describes wild rubber, plantation rubber, domestic rubber, synthetic rubber, and integrates the whole into a story which gives a reasonably complete grasp of the rubber situation as it stands today. *The B. F. Goodrich Company, Akron, Ohio.—Gratis.*

SAVE WITH "BALANCED" LIGHTING is a 10-page pamphlet which tells in text, drawings, and photographs how best to apply local and general lighting so that a balanced, efficient, and economical condition results. *The Fostoria Pressed Steel Corporation, Fostoria, Ohio.—Gratis.*

UNIVERSAL ANGLE DRIVE is an eight-page illustrated folder describing a bevel-gear drive for manual operation of valves and other devices on shipboard and in industry. *Payne Dean and Company, Dean Street, Laconia, New Hampshire.—Gratis.*

ALGOMA TEMPLATE DIES is a four-page bulletin describing a new process of manufacturing blank and pierce template dies at a fraction of the cost of conventional dies. *Algoma Products, Detroit 12, Michigan.—Gratis.*

HANDBOOK OF EMERGENCY WAR AGENCIES is a 144-page publication which outlines briefly the function and organization of Federal War Agencies as well as Army and Navy Departments and the Maritime Commission. Names, addresses, and telephone numbers of principal officials are listed. *Superintendent of Documents, Government Printing Office, Washington, D. C.—20 cents.*

VERY PROMPTLY YOURS, by Robert E. Ramsay, is a 16-page booklet pertaining directly to office correspondence. It gives suggestions for filing and cross-filing, for a simple letter-writing plan, and for speeding up correspondence. *Hammermill Paper Company, Hammermill Road, Erie, Pennsylvania.—Gratis.*

VEGETABLE DYES is a 56-page pocket-size book which tells specifically how to make dyes at home from barks, weeds, berries, and fruit. *Oxford University Press, University Avenue, Toronto 2, Ontario, Canada.—35 cents.*

MOGUL METALLIZING PROCESS AND EQUIPMENT is an illustrated pamphlet describing the metallizing process for building up worn metal surfaces, to render exposed surfaces corrosion resistant, and so on. Also presented are specific applications of the process, and a listing of the equipment necessary for metallizing. *Metallizing Company of America, 1330 West Congress Street, Chicago, Illinois.—Gratis.*

SOME FUNDAMENTALS OF TIMBER DESIGN, by Howard J. Hansen, is a 76-page booklet which covers characteristics influencing design, methods of fastening wooden members together, types of beams and columns, and glued laminated construction. Numerous valuable tables and charts are presented. Bulletin No. 66. *Texas Engineering Experiment Station, College Station, Texas.*

REVIEW OF "PATENTS AND FREE ENTERPRISE" Monograph No. 31, Temporary National Economic Committee, is a pithy comment on Walton Hamilton's monograph, as presented by Anthony William Deller, a patent attorney and member of the New York Bar. This review is a plea for the protection of inventors and their rights under the patent system. *Anthony William Deller, 67 Wall Street, New York 5, New York.*

CENTRIFUGAL CASTINGS is an eight-page folder which tells briefly how a centrifugal casing is made, lists the wide ranges of sizes available, and tabulates the chemical and physical properties of a number of standard alloys which are cast by the centrifugal process. *Shenango-Penn Mold Company, Dover. Ohio.—Gratis.*

CELESTIAL NAVIGATION FOR AVIATORS, by Clarence H. True, is a 32-page llustrated booklet offering a method by which spherical triangles are solved without spherical trigonometry.—*Clarence H. True, Civil Engineer, Box 318, Balboa Heights, Canal Zone.—$1.50 postpaid.*

CURLED CHIP METAL CUTTING SYSTEM is a lavishly illustrated plastic bound catalog which presents what is termed "an amazing and revolutionary advancement in metal cutting history." Descriptions and photographs are presented of saws designed in accordance with this new system. *E. C. Atkins and Company, Indianapolis, Indiana.—Gratis.*

CARBONIA is a four-page folder describing a process for obtaining a gun-metal finish on ferrous metal parts. This finish is applicable to many articles in bulk and is applied at the same time that the work is tempered. *American Gas Furnace Company, Elizabeth, New Jersey.—Gratis if requested on business letterhead.*

HOW TO BRAZE WITH PHOS-COPPER is a 12-page booklet describing the use of a brazing alloy which can be used with gas, incandescent carbon, electric furnace, and dip brazing methods. Request Booklet B-3201. *Westinghouse Electric and Manufacturing Company, Department 7-N-20, East Pittsburgh, Pennsylvania.—Gratis.*

Telescoptics

A Monthly Department for the Amateur Telescope Maker

Conducted by ALBERT G. INGALLS

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

YERKES was a Chicago traction magnate with plenty of wealth. The late Dr. George Ellery Hale tactfully made him realize that man is mortal and that after a few years the world would forget his name and his multi-millions, but by donating a big telescope to science, he could become an immortal. Hale got the money for the 40" telescope and Charles T. Yerkes got his immortality—which included burial in a crypt in the telescope's pedestal.

Amateurs who have made exceptionally good telescopes may, too, become immortals without the bother and annoyance of being rich, by dedicating these instruments to some educational institution or other corporate body (the burial beneath is not a requisite; in time it might even prove embarrassing). Cyril G. Wates, 7718 Jasper Ave., Edmonton, Alberta, whose 12½" Newtonian reflector (Figure 1) was briefly described in this department in December 1941, has now thoughtfully dedicated it to the University of Alberta, at Edmonton, Alberta, Canada.

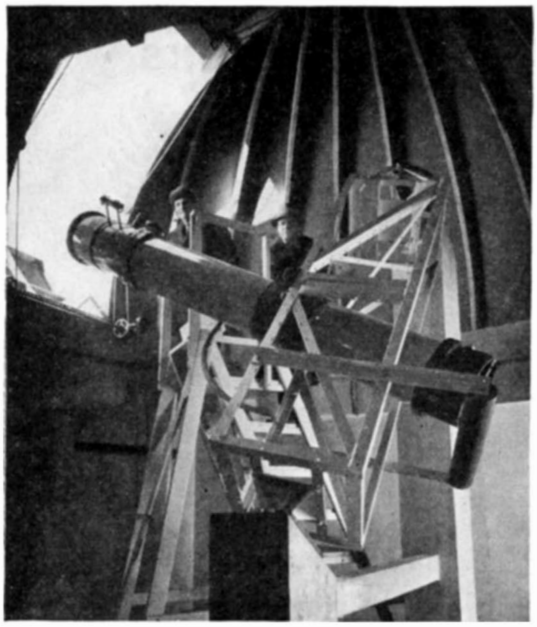


Figure 1: Wates (left) and telescope

Figure 2 shows the group present at the ceremony. Wates stands between Hon. J. C. Bowen, Lt.-Governor of Alberta (with cane) and (toward the reader's right) Dr. R. Newton, President of the University. There were ceremonies, Dr. J. Pierce, Director of the Dominion Astrophysical Observatory at Victoria, B.C., gave the address, and Wates, not brawny enough to hand the president the telescope, handed him the eyepiece instead. Such a party is a Big Day for the donating immortal.

Asked to describe the telescope and dome, Wates writes:

"The 12½" mirror is Pyrex, ground and polished by hand, but figured on a Hindle machine. Focal length 110". The tube is cedar, glued up from 20 strips and then turned. It is strengthened with cast-iron rings. Just above the mirror cell is a lead counterweight, made in four segments and encircling the tube. The head of the tube, carrying the finder, eyepiece adapter, and 2" Bausch and Lomb prism, rotates on ball bearings, and is turned by a handwheel and pinion working in a circular rack, which was filed out with the aid of a hardened steel template.

"The finder is a 4" RFT with aluminum tube. There are no cross-hairs, as the telescope is to be used for clusters and so on as well as for a finder.

"The main tube is mounted in a frame of 2½" angles, in a similar manner to the 100" at Mount Wilson, but the declination bearings are offset a foot from the polar axis, to provide greater accessibility to the circumpolar stars. There is a 150-pound counterweight to balance the tube.

"The lower end of the polar axis rests in a conical roller bearing, and the upper end turns in a heavy ball bearing. Provision is made for adjustment of both axes, by means of push screws. The drive, not yet installed, will be a modification of the Boyd Brydon drive, with a slip clutch.

"The declination scale is a strip of Celluloid, engraved with a tool made from a Schick razor blade and stamped with steel letters from an old Addressograph. This scale is bent around a semicircular block attached to the polar axis frame, and is viewed by means of a simple periscope from a point close to the main eyepiece. The hour angle scale is an iron hoop 3' in diameter, enamelled white and carrying black markings.

"The main dome is an exact copy of the dome of the observatory at the Rensselaer Polytechnic Institute, Troy, N. Y., and was built from blueprints furnished by Dr. Carragan of that institution. The ribs are cedar, with a covering of Masonite, painted aluminum. The slit is fitted with a curved shutter, conforming to the dome and moved by endless chains running on sprockets, operated by means of a worm gear hoist.

"South of the dome is an extension with a roll-off roof, housing a 4" refractor, a transit, and a zenith telescope. These instruments and the reflector are mounted on heavy concrete piers running below frost line—which is about six feet in these parts! The mounting for the refractor was built locally from my designs, and works very smoothly."

Because of cramping and bad lighting it is notoriously difficult to take a good photograph of a telescope within a dome. This hazard was obviated by using a combination of daylight and flashlight—a point possibly worth remembering.

ONE way to lay out a setting circle is to make full use of the work already done by others in laying out gears. Figures 3 and 4 show how one amateur, a Wyoming physician who prefers anonymity, did the job, and are almost self-explanatory when studied.

In Figure 3 the blank is being faced in a lathe. In Figure 4 is the special set-up devised by the doctor, consisting of an 80-tooth wheel bolted to the headstock spindle, a supporting piece screwed to the bench, a 72-tooth wheel, and a ratchet engaging the latter. Figue 3 reveals the missing small gear, having 16 teeth.

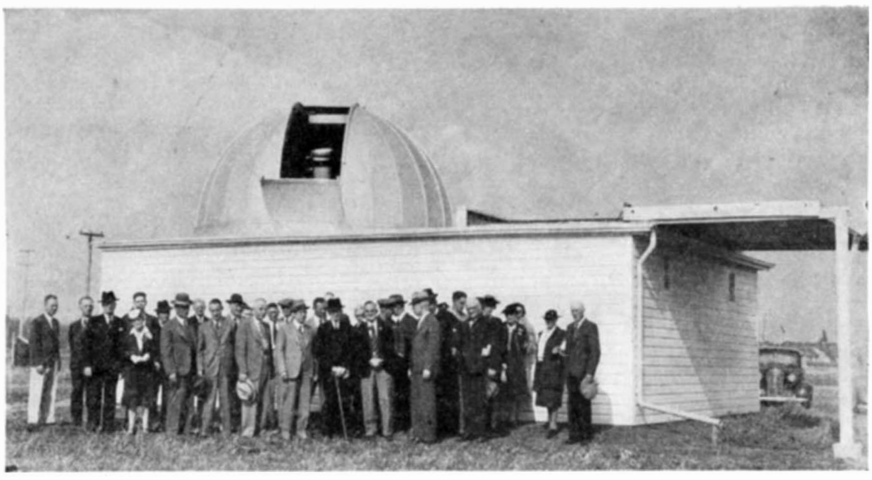


Figure 2: Wates with celebrities at the dedication ceremony

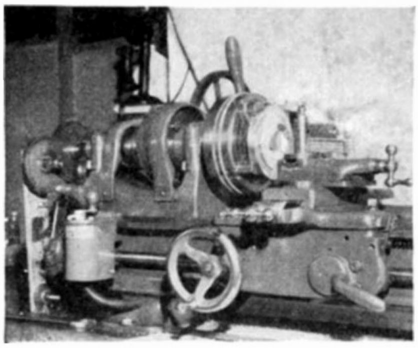


Figure 3: Facing setting circle

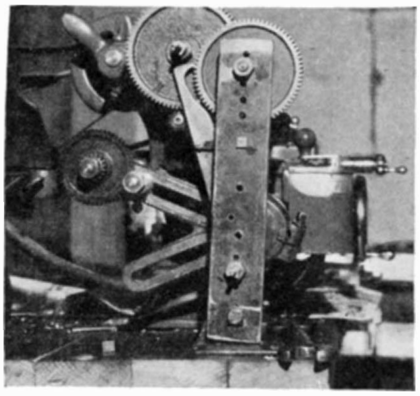


Figure 4: The spacing set-up

The ratchet, working on the 72-tooth wheel, would alone give divisions of 5°. To reduce these to single degrees a 16-tooth wheel on the same spindle meshes with the teeth of the 80-tooth wheel, giving a reduction of 5 to 1.

The ratchet has a rubber band spring. The maker states that, using a carbide tool ground to a long taper and whetted on an oil stone, he was able to make the degree marks on a 4″ blank in about 40 minutes.

Lesser details and the maker's name and address are available to especially interested readers.

JOHN R. HAVILAND, 426 Second Ave., Lyndhurst, N. J., author of the famous book-length chapter on the objective lens, in "Amateur Telescope Making—Advanced," sends us the following on the Barlow lens:

"So many inquiries have been made regarding Barlow lens behavior that the following is submitted to relieve my 'homework' on the subject.

"In July, 1937, the method of designing a Barlow lens was described [also by Haviland.—*Ed.*] in this column but no exposition of what happened in a telescope system was included. So here goes:

"In 'A.T.M.A.', page 231, there appears the formula for separated lenses, viz., $F = (f_1 \times f_2) \ / \ (f_1 + f_2 - d)$, where F = focus of combination, f_1 = focus of telescope objective, f_2 = focus of Barlow lens, and d = distance between the two lenses.

"Suppose we had a Barlow of focal length −18″ (minus because the lens is diverging or negative) used with a 6″ reflector of 48″ focus. Suppose further that the Barlow is placed 2″ inside the focus of the mirror. What is the new focal length? What is the magnifying power? We get out our pencil:

"Substituting in the formula:

$F = (48 \times -18)/(48 - 18 - 46) = -864/-16 = +54.$

"Note that the eyepiece has to move 6″ out to the new focus. As the Barlow moves in toward the mirror the eyepiece moves out and the magnification increases.

"The magnifying power of this combination may be found by dividing the length of the cone cut off by the Barlow into the length of the new cone formed (Hindle, in 'A.T.M.', page 215). Referring to Figure 5 it will be noted that the cone cut off is 2″ long and that the new cone is 8″ long. The quotient of these is 4. Thus the magnifying power is equivalent to that of a telescope having four times the focal length of the original.

"A magnifying power of four is about the maximum desirable. Make the Barlow lens of sufficient diameter to include slightly more than the diameter of the cone of light from your objective when the Barlow is placed as far within the focus as it will be used. ¾″ would be about right for the example above, since a ½° diameter field is about this size 2″ inside of focus in a 48″ focus telescope.

"As in any system which magnifies, the intensity of illumination goes down. In the above example the image of the Moon would be about 2″ diameter. No ordinary eyepiece would accept an image this size. The illumination when using a 1″ (equivalent focal length)

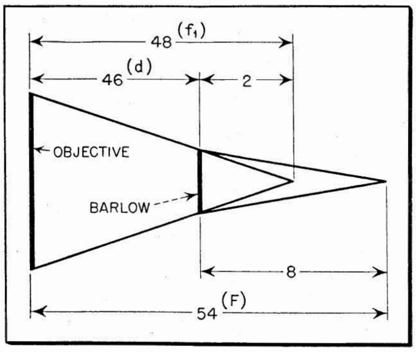


Figure 5: Barlow lens layout

eyepiece with the Barlow will be the same or better than when using a ¼″ eyepiece without it—the magnification being the same in each case.

"The advantage of the Barlow is that the cone of light from it has a more acute angle at the vertex than the cone from an $f/8$ reflector. Thus, cheap eyepieces (Huygens or Ramsden) will perform satisfactorily with it and will be comparatively free from the bad color and spherical aberrations which they produce when fed the wide angle beam from a large aperture-ratio objective. Despite the imperfect achromatism of the Barlow, the overall result will be an improvement over the common reflector and Huygens eyepieces. Most of us can't afford the trick eyepieces needed to give good color correction on reflectors, so the Barlow is an easy way out of this difficulty, as well as furnishing an exercise in making an achromatic lens of not too rigorous limits of figure and achromatism."

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.

Conducted by JOHN P. CANDIA

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HEAT TREATMENT OF METALS

By J. Winning

Condensed yet fairly complete is this straightforward account of heat treating methods and the underlying principles on which they are founded. Although essentially concerned with British practice, the text will be of value to industrial engineers in this country who have need for a generalized survey. (100 pages, 5½ by 9 inches, 39 drawings and photographs.)—$1.60 postpaid.—*J.P.C.*

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By F. Twyman

The managing director of Adam Hilger Ltd., Britain's outstanding precision optical producer, and inventor of the well-known Twyman interferometer, reveals in this new, compact text book the meat of what he has learned in a long lifetime about practical shop work. Content: Historical; elements of single lens working; nature of grinding and polishing; tools and materials; quantity production of lenses and prisms; centering, edging, and balsaming; making and working blocks of prisms; testing optical work; testing optical glass. The American optical industry has already sought this new book eagerly (roof-prism producers of amateur origin speak highly of it). Of what use would so expensive a book, ostensibly on professional quantity production, be to amateur telescope makers? To the tyro, almost none. Nor will advanced amateurs find it a full step-by-step manual. It is more in the nature of a wide variety of notes, any single one of which may justify the purchase, a single short note often embodying the invaluable essence of years of costly shop experimentation, and as basically applicable and revealing in single-piece work as in mass production. It seems conservatively safe to predict that, eventually, hundreds—perhaps thousands—of advanced amateurs will place this excellent working aid next to "A. T. M. A." on their shelves. (178 pages, 5½ by 8½ inches, 63 illustrations.)—$4.60 postpaid. —*A.G.I.*

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By Harold L. Ickes

Oil, life-blood of civilization and particularly of modern military operations, is a far more complex subject than the average person appears to realize. Thus the thoughts of Mr. Ickes, set forth here in pungent, straight-from-the-shoulder exposition, are worth more than casual attention. The text surveys the need for oil, how to conserve it, how it is being used in a number of ways, and all the other ramifications of this important subject. (174 pages, 5½ by 8 inches, a few drawings and photographs.)—$1.75 postpaid.—*A.P.P.*

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By Samuel R. Williams

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INDUSTRIAL RADIOLOGY

By St. John and Isenburger

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HOW OUR ARMY GREW WINGS

By Charles DeForest Chandler, Late Colonel U.S. Army, and Frank P. Lahm, Brigadier General, U.S. Army, Retired

BOTH of the authors played distinguished personal parts throughout the development of Army aviation and are essentially fitted by experience, knowledge, and personal character to write an impartial, well-documented, and almost definitive account of the progress of our Air Corps. The book grew from voluminous notes and correspondence left by Colonel Chandler, who first conceived the idea of the book as an informal batch of reminiscences. Colonel Chandler's project became more ambitious as he went along and, fortunately, General Lahm could complete the work after Colonel Chandler's death.

The book is a fine record of great historic events, dealing with the pioneer period of Army aeronautics and ending appropriately with the Act of July 8, 1918, which approved formation of the Aviation Section of the Signal Corp. (333 pages, 32 illustrations.) —$3.85 postpaid.—*A.K.*

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By William Floyd

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